THE MILK PROBLEM IN INDIAN CITIES

WITH SPECIAL REFERENCE TO BOMBAY,

BY

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WITH A

FOREWORD

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THIS WORK

IS RESPECTFULLY DEDICATED TO

His Excellency Lord Willingdon, G.C.I.E.

THE GOVERNOR OF BOMBAY,

AS A TOKEN OF SINCERE APPRECIATION OF

THE KEEN INTEREST HE HAS TAKEN

IN THE IMPROVEMENT OF THE

MILCH CATTLE OF INDIA.

FOREWORD.

The very unsatisfactory state of the milk supply of large towns in India has long been realised, but it is only within the last few years that the subject of improving it has received the attention which it deserves.

In Bombay and other large Indian towns, dairies have been established by private enterprise, in which a fairly good attempt is made to handle milk by Western methods. But these establishments cater for the well-to-do classes, who alone can afford to pay the high prices charged for milk at these places. The problem which, therefore, usually confronts the Health Officer in India is how to obtain a reasonably pure and wholesome milk-supply at a moderate price from indigenous agencies, *viz.*, the *gowlee.*

It is well known that milk is stored by these *gowlees* in dirty hovels, the brass milk vessels undergo a process of so-called cleaning by being scrubbed with mud obtained from filthy sources, and milk is carried long distances in open cans with a wisp of dirty straw floating in it to prevent spilling.

The milk problem is a difficult one in Western cities, but it is doubly so in India, and the book Dr. Joshi has published will be a welcome addition to the meagre literature on the subject to which the public has had access hitherto, as it deals exhaustively with the many and varied aspects of the milk supply in India.

In Bombay, for many years, we have been struggling with the question, and, although some slight improvement may be noticed, unless and until the matter is dealt with seriously, no substantial improvement will take place.

Since 1904, in the Bombay Municipal Laboratory, milk has formed one of the most important matters dealt with, and Dr. Joshi has made it a special study and has sum-

marised the work done in other cities, and the treatise he now lays before the public is a valuable contribution on the subject.

The demand for pure milk in large towns in India is increasing rapidly, but the supply is not equal to it.

Inquiries have been made into the quantity of milk consumed by different classes of people, and we find that amongst the poorer classes very little is consumed, and what is used is of a very inferior quality.

Many local authorities in England realise the difficulty the poorer classes have in the way of obtaining milk and have provided pure milk depots at which milk is provided at cost price.

The protection of milk from dirt and contamination has been the subject of much discussion in all Western cities, and strong legal provisions are enacted. In America, the regulations for the control of milk are most stringent.

In Bombay much progress has been made in the direction of legislation and the regulations for the licensing of milk sellers, but many difficulties must be overcome before we can hope for much improvement. The work of Dr. Joshi will place, in the hands of the public, information which should enable them to co-operate with the authorities; without such co-operation little can be done.

J. A. TURNER.

BOMBAY, *6th January,* 1916.

PREFACE.

The chemical analysis of Bombay milk was first undertaken in the Bombay Municipal Laboratory in 1905. A systematic examination for Tubercle bacilli in milk was made by the author during four years (1910-13). In the early part of 1913, a special investigation was started regarding the bacteriological and chemical examination of the Bombay milk supply. This has been continued for nearly three years. The original object of the investigation was to study the normal composition of milk and its variations under different local conditions ; to find out the kind and amount of adulteration ; to detect and measure the contamination of milk and to establish chemical and bacteriological standards for Bombay. A preliminary paper was read at the Third All-India Sanitary Conference at Lucknow. It was soon found necessary, however, to widen the scope of the enquiry and to study various other phases of the milk problem including the economic, sanitary and legal aspects.

There are numerous publications available on the milk question in Europe and in America ; but here in India, with the exception of scattered articles in journals and periodicals, very little literature has been published so far on a subject which is of great importance to the Public Health. The present investigation deals with the milk problem as it exists mainly in the city of Bombay, but may be applied with some modifications to most of the large cities of India. Reference is made to Calcutta, Madras, Delhi, Poona, Bangalore and other cities from time to time. It cannot possibly cover the entire field, but the main aspects of the milk problem, including Remedial Measures, are dealt with briefly. The physiology of milk as well as the details of the methods used for chemical analysis and bacteriological examination have been omitted, as these can be easily found in most Text-Books.

The increased interest recently shown in this important subject by Government, Municipal Corporations and the public makes the author hope, that in spite of any possible defects or shortcomings, the book would serve a useful purpose.

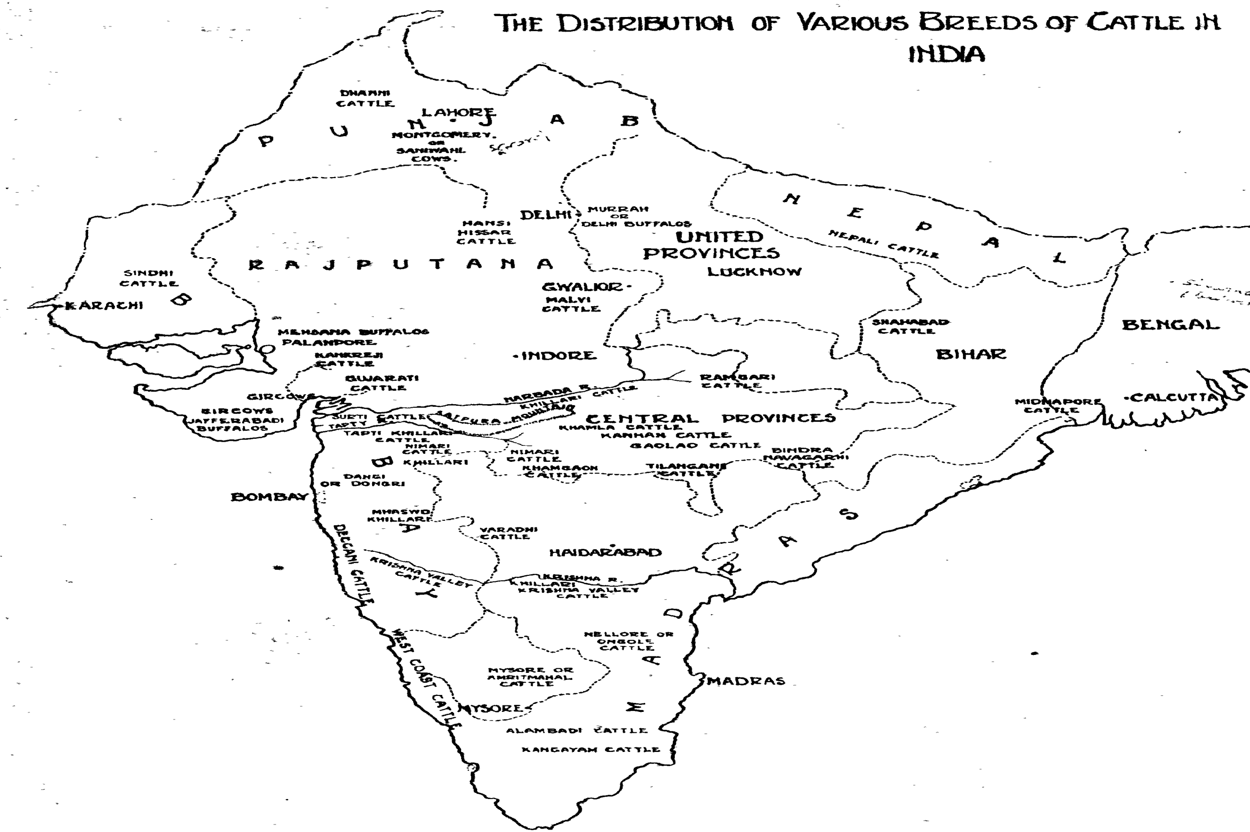
I must express my gratitude to the Bombay Municipal Corporation for their generous contribution towards defraying part of the cost of printing this work.

I have to acknowledge my indebtedness to numerous friends, both in this country as well as in Europe and in the United States of America, who have very kindly supplied me with valuable reports, statistics, etc. These sources of information are acknowledged in the text. Special mention must be made of important information furnished by Mr. G. H. Frost, Dr. H. H. Mann, the Directors of Agriculture of different provinces, the Health Officers of Calcutta, Madras and Delhi, the managers of Government Dairies in Bombay, Kirkee, Ahmedabad, Bangalore and Peshawar. I have to express my sincere thanks to Dr. J. A. Turner, for writing the Foreword; to my assistants, Messrs. Gupte, Pansare and Nadkarni, for assisting me in the Laboratory Research work; to Dr. C. Coutinho for helping in the preparation of the index, and to Mr. S. V. Gupte for assisting me in the correction of proofs.

L. L. J.

Municipal Office, Bombay,
February, 1916.

THE DISTRIBUTION OF VARIOUS BREEDS OF CATTLE IN INDIA



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THE MILK PROBLEM IN INDIAN CITIES
WITH SPECIAL REFERENCE TO BOMBAY.

CHAPTER I.

GENERAL CONSIDERATIONS.

THE problem of supplying pure and clean milk to large cities has been found to be a very difficult and perplexing one and has not been satisfactorily solved even in Europe or in America. Rosenau of the U. S. A. says: "There is probably no single problem in the whole realm of modern sanitation and hygiene that is so complex, so involved, so intricate, and so harassing." If this is so in a very progressive country like the United States, it is much more true in India, where the milk supply is in a most deplorable condition. This may be ascribed to various factors, such as climatic influences, peculiar customs and habits of the people, illiteracy and ignorance of the farmers and of the ordinary milk vendors, lack of proper sanitary and legislative control, &c.

The milk problem may appear very simple to the casual observer, being only a part of the larger problem of Pure Food. A deeper study, however, would disclose the fact that the milk problem is one of the most complex problems in public sanitation. There are several reasons why we have a milk problem. In the first place, milk is almost an universal article of human food, and is used in all civilised countries. Secondly, milk is likely to convey disease *directly* by pathogenic microbes when it is polluted, or to cause it *indirectly* when it is adulterated. Example of the former is tuberculosis and that of the latter is rickets, as a result of malnutrition due to milk being adulterated with water. Milk is an essential article of diet during infancy and early childhood. It is a perfect food not only for infants but also for bacteria which grow abundantly in it. Another reason why we have a milk problem, particularly in Indian cities, is because it is well nigh impossible here to obtain milk which has been handled with scrupulous care and cleanliness. A further reason is that, in this climate, milk decomposes more quickly than any other food. Hence it may be assumed that every sample of milk is *likely to become dangerous to health.*

In India, milk holds the first place in the dietary of the people and is used universally in some form or other. Milk and milk products such as curds, butter-milk, butter and ghee are used particularly by the middle and the high classes. Tea is rapidly becoming the national drink of India, and in large cities like Bombay, most people of every race, caste, colour and creed partake of tea. A great deal of milk is used up in this manner. Milk is also used in making "Khawa," "Mawa," "Basundi," and sweetmeats, such as "Pedhas," etc., which are peculiar to India and which are consumed in large quantities by all classes.

There are several aspects of the milk problem in India which demand a thorough investigation on the part of the Scientist, the practical Sanitarian, the Economist, the Dairy Expert, the Sociologist and the Legislator.

(1) First, we hav the **sanitary aspect** of the milk problem. This involves (*a*) a study of the various sources of the city milk supply and of the manner in which milk is collected and distributed, including an investigation of the different conditions affecting the milch-cattle, *e.g.*, their housing, feeding, breed, disease, etc., and their effects on the quantity and quality of the milk produced ; (*b*) a chemical and bacteriological investigation of the milk supply with a view of finding out the composition of Indian milk, the kind and extent of adulteration and the amount of pollution present ; (*c*) the relation of milk to the public health ; and (*d*) a study of the practical sanitary measures (such as inspection of the cattle-stables, the dairies, etc.) which can be readily applied and are most suitable to conditions as they exist in India.

(2) Secondly, there is the **social side** of the milk problem : this is of special importance here in India. The intricate caste-system, the religious beliefs and the social customs of the people, the illiteracy of the masses, the domestic habits of the people, &c., are all important factors and have some bearing on the milk problem. The customs and habits of the people who deal in milk are most unfavourable to the production of clean and wholesome milk. The method of milking, the modes of transportation, etc., are greatly objectionable from a sanitary point of view. **Education,** in the broadest sense of the term, is essential to overcome ignorance, prejudice and indifference ; education alone would give the people a keen sense of appreciation of public sanitation and personal hygiene. Without the intelligent and

active co-operation of the milk dealers, it would be hardly possible to apply any practical remedies to the solution of the milk problem. The milk problem thus involves a systematic and sympathetic study of the various conditions of social and domestic life in the city as well as in the country, and the devising of ways and means for the removal of unfavourable conditions by means of education, etc.

(3) Thirdly, we have the **economic side.** The improvement of the milk supply of Indian cities is primarily an economic problem. In some respects it is of the greatest importance in India, where an appalling amount of poverty prevails among the people, and where the dairy industry is in a very bad condition. As will be shown in this memoir, it is extremely difficult to get genuine milk in Bombay for less than four annas per seer (about 6½ pence or 13 cents per quart). This rate is considerably higher than that in most large European and American cities. It indicates that there is something radically wrong in the cost of production and distribution of milk, particularly when one remembers that labour is cheaper in India than in Europe or in America. The economic aspect of the milk problem also involves the question of scientific breeding, sanitary housing and proper tending of the milch cattle, the provision of cheap fodder, the supply of plentiful and clean water, suitable and modern modes of rapid transit, the establishment of model cattle-stables and modern dairies on co-operative basis, etc., etc. Unless there is a vast improvement in the present methods of production and distribution of milk, the price is likely to remain very high. It is quite possible that if the new legislation be rigorously enforced, the price of milk might be raised still higher and it would then be impossible for even the higher classes to obtain a sufficient quantity of pure milk. Instead of being an universal article of diet, milk might become a luxury only for the rich.

(4) Fourthly, **milk legislation.** The legal aspect of the milk problem is quite new to India. The Government of Bombay, after considering the representations of the Bombay Municipal Corporation, have only recently passed an Act (Bombay Act VI of 1913) for the sanitary control of the milk supply of Bombay. This is the first attempt at milk legislation here and it would be instructive to watch its effects. All the dairymen, dealers, importers, or sellers of milk are now required to hold licenses in Bombay. The new legislation was enforced for the first time

on April 1st 1914, when there was a temporary "strike" of the milk dealers and it was very difficult to get any milk for a day or two. It appears that since then there has been a slight rise in the price of milk in Bombay. Legislation of some kind or other is, no doubt, necessary for the effective sanitary control of the milk supply in India; but if that would render the economic problem more complex by causing a further rise in the existing high price of milk and thus making it practically impossible for the masses to obtain pure milk, then such legislation may be open to question from the economic point of view. Adequate measures for the economic production and supply of milk should *precede* legislation. In other words, legislative measures should result, if possible, in the *improvement of the milk supply without an appreciable increase in the price.* It is quite evident that legislation alone can never solve the milk problem in India. Many other measures are necessary to remedy the existing evil and these will be dealt with, at a later stage.

After analysing nearly 1,400 samples of milk it has been shown [1] that *four-fifths of the milk supply of Bombay is adulterated with water*, and over 90 per cent. of the milk samples examined bacteriologically are *contaminated with microbes whose presence indicates dirt, etc.* In Poona and Bangalore [2] milk has been found to be adulterated with water to the extent of 80 per cent. and 78 per cent., respectively. A similar state of affairs, no doubt, exists in Calcutta, Madras, Delhi and other large Indian cities. This has a very important bearing on the public health, and particularly on infant mortality. Milk in India is not only adulterated and contaminated but is also very costly. As remarked by the Government of India in Resolution No. 888-908 of the 23rd May, 1914:—

"The adulteration of milk is almost universal in Indian bazaars and a large proportion of the milk consumed is contaminated. In most cities the milk supply is in the hands of men ignorant of the elements of sanitation and addicted to uncleanly practices. Moreover, the milk when stored and in transit to market is liable to contamination in several ways. On the other hand, the price of milk is already very high and the problem of improving the purity of the supply without increasing the price

1 "Observations on the Chemical and Bacteriological Examination of the Milk Supply of Bombay," by Dr. Lemuel Lucas Joshi, being a preliminary paper read before the third All-India Sanitary Conference at Lucknow in January 1914.

2 *Vide* papers on milk read at the same conference by Dr. Mann and Dr. S. Rau

to such an extent as to cause hardship to the poorer classes is a difficult one."

The milk trade in the large cities of India represents an outlay of a considerable amount of capital. If the total daily milk-supply of Bombay be calculated at 265,000 pounds, at the rate of two annas per pound, the value of the milk would exceed *Rs.* 33,000 *per day, or about one crore and twenty lakhs of rupees per year.* In Calcutta [3] the value of milk consumed every year is estimated at about 75 lakhs or *three-quarters of a crore* of rupees. Considered from a financial point of view, there are great possibilities if the dairy business in this country was organised along economic and scientific lines. Improvement of the milch cattle alone would result in a considerable increase in the net income. The number of milch cattle in the city of Bombay and suburbs may be taken at about 30,000. If these animals could be improved so that each buffalo and cow would give on the average, say, two rupees worth more milk per month (or Rs. 24 per year per animal) this would mean an additional income of more than seven lakhs (Rs. 700,000) per annum without much initial expense.

The dairy industry of India is acknowledged to be in a very bad condition and is in need of a thorough organisation along modern lines. Some of the principal facts regarding the milk problem in Indian cities may be summed up as follows :—

(1) The supply of milk in the cities is deficient in amount.

(2) The quality of milk supplied is bad from a chemical as well as from a bacterial point of view, the milk being adulterated as well as contaminated. This has an important bearing on the public health in India, particularly with reference to infants.

(3) The Indian milch cattle are very poor milkers and appear to be deteriorating. This is due to several causes, *e.g.*, lack of scientific breeding, want of proper feeding, tending and housing, etc.

(4) The milk trade of Indian cities is mostly in the hands of the city *gowlee* who has no idea of the principles of economic dairying and who is quite indifferent to the laws of hygiene and sanitation.

(5) Part of the milk supply of the cities is from the neighbouring villages where the ordinary *cultivator* keeps a few buffaloes and cows and supplies milk under expensive and very insanitary

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[3] "Journal of Dairying," Vol. 1, Part 3, April 1914, p. 225.

conditions; his ignorance and apathy are just as profound as that of the *gowlee.*

(6) The price at which milk is sold in large cities like Bombay and Calcutta is very high and likely to rise higher unless there is considerable improvement in the present methods of production and distribution of milk.

(7) There is considerable room for improvement both in the sanitary supervision and legislative control of the milk trade in India.

Briefly stated, the problem before us is to study the various phases of the milk question in India and to find out the most scientific, economic and effective methods for the production and distribution of pure milk to the cities in large quantities and at a moderate price.

CHAPTER II.

INDIAN MILCH CATTLE AND THE MILK SUPPLY OF INDIAN CITIES.

The number of cattle (bulls, bullocks, cows, buffaloes and young stock) in India amounts to the enormous total of 139 millions,[1] an increase compared with the number a decade ago. The United Provinces account for 11 per cent. of the total number, Bengal 19 per cent., Madras 14 per cent, Bihar and Orissa 12 per cent., the Central Provinces and Berar 9 per cent., the Bombay Presidency including Sindh only 7 per cent. According to Keatinge[2] the number of cattle in the Deccan amount to 3,400,000 of which about one-sixth are buffaloes. The plough bullocks amount to 1,315,000 and the plough buffaloes to 55,000. The total number of cattle in the Bombay Presidency (excluding Sindh) is given as 7,529,792. Out of this, 2,614,798 were plough oxen, 214,691 were plough buffaloes (male), 587,853 were cows and 868,746 were she-buffaloes. The excess of oxen over cows, and of female buffaloes over male buffaloes is very marked. The fact that the female buffaloes are nearly four times as numerous as the males indicates that *the buffalo is par excellence the milk animal* of the country.

The dairy industry in India is admitted to be in a most unsatisfactory condition. This is in a great measure due to the fact that the indigenous breeds of milch cattle—particularly. cows —are very poor milkers. With the exception of the Government dairies and a few private farms, no systematic attempt seems to have been made regarding scientific breeding in India. From numerous enquiries made, it appears that the Indian milch cattle show a *deterioration* in quality, and that the number of good animals is rapidly diminishing. This may be ascribed to the following causes :—(1) Lack of scientific breeding. (2) Exportation of the best animals to foreign countries. (3) Removing certain breeds of cattle to other parts of the country where the climatic and other conditions are not suitable for them. (4) Supplying the large cities with thousands of milch cattle, which

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[1] "The Times of India," Thursday, May 13, 1915, " Indian Agriculture. Its strength and

[2] G. Keatinge, I. C. S., "Rural Economy in the Deccan " 1912

eventually fall into the hands of the butcher. (5) Occasional famines. (6) Defective feeding and tending. (7) Neglect of proper rearing of calves.

Notwithstanding the numerous adverse factors and crude methods of breeding, it is surprising to find that there are so many well-defined and pure breeds of milch cattle in India. Among the best breeds of cows may be mentioned *Sindhi, Gir, Saniwahl* and *Hansi,* and among the buffaloes, the *Delhi* or "*Murrah*" *Surati* (Gujarat) and *Jaffrabadi* (Kathiawar). There is hardly anything known regarding the original stock from which each breed has sprung. It is possible that the breeds of cattle found to-day in India differ a great deal from their original progenitors. The fact that many pure breeds have a distinctive type and family likeness seems to indicate that this may have been the result of careful breeding through many generations. It may be also due to the fact that until recent times, the local breeds have been limited to their own habitat and rarely taken to other districts, so that they have developed into a specific type characteristic of a particular district.

Some of our best dairy animals are reported to be exported to Argentina, Uganda, Japan, Burmah, the Phillipines and other countries, but no statistics are available as to the exact number thus exported from India.

The best breeding grounds in India for milch cattle are the plains of the Punjab, Sindh, Kathiawar and Gujarat. Certain breeds of cattle when removed from their own habitat to other parts of India show deterioration. For instance, a Hansi cow when brought to Bombay from its home in the Punjab (Hansi-Hissar District) does not flourish but deteriorates. Similarly, when certain milch breeds are taken to the hills from the plains, the yield of milk is known to drop by as much as 20 per cent.

The slaughter of "dry" animals in the large cities probably accounts to some extent for the diminution in the number of good milch cattle in India. Most of the cows and buffaloes in Bombay are either sold to the butcher when dry, or are sent to the country for grazing. According to the Chief Veterinary Inspector of Bombay, out of the *dry* animals, 75 per cent. are slaughtered and only about 25 per cent. are sent out to the country. During the year 1914-15 at the Bandra Slaughter House (near Bombay) 44,177 cows and 8,574 buffaloes were slaughtered. Out of this number about 3,000 cows and all the buffaloes were from the

Bombay milch cattle stables. During the same period about 5,000 buffaloes were slaughtered at Kurla, making a total of about 13,600 Bombay buffaloes killed in one year. It is calculated that from 40 to 45 per cent. of all the buffaloes in Bombay find their way to the slaughter house. This means an appreciable drain on the milch animals of the country, and its effects would be keenly felt if a fresh supply of animals were not forthcoming. In Calcutta, 9,147 cows were slaughtered during the year 1913. The Special Committee on the Milk Supply of Calcutta in their report recommended that "the slaughter of prime cows should be discouraged and the fee for slaughtering such cows should be tentatively raised to Rs. 10." The Committee evidently felt that this is a distinct loss to the country.

There was a considerable loss in milch cattle during the famine of 1899-1900, as will be seen from the following figures :—

Number of Milch Cattle in the Bombay Presidency, excluding Sindh and the City of Bombay.

	1894—1895	1909—1910
Cows ..	..1,892,404	1,587,853
Buffaloes ..	.. 968,952	868,746

This decrease in number is ascribed to the famine of 1899-1900. There has been a definite increase in the population, but the number of cattle has not kept pace with the increase in population. The loss of cattle during famine may not be considered very serious if it results in the "survival of the fittest" by the elimination of numerous useless cattle which are to be seen all over the country. It may be stated, however, that since 1900 there has been a steady rise in the price of milk, butter and ghee. The price of good animals also has considerably risen recently. Defective feeding and careless tending is partly responsible for the deterioration of Indian milch cattle. The former is common among small owners in the country, while the latter is to be seen on large dairy farms where the hired men do not care to tend the animals properly.

The raising of young stock is also neglected to a large extent in this country. This is particularly so in the case of buffalo

calves, and constitutes a serious evil. In Bombay and other large cities, as it is unprofitable to rear a calf, the town *gowlee* allows it to die of neglect. This means a serious loss to the country of a large number of calves of good milch buffaloes.

The tendencies of good milch cattle and their progeny to deteriorate has been noticed in the Poona Civil Dairy and a few other dairies. The cows as well as buffaloes brought from outside are known to deteriorate in subsequent lactations. This cannot be attributed to any defects in feeding or housing, but is probably due to defective breeding and careless tending. In Bengal, it has been found that the milk yield of imported cows becomes smaller in quantity after each calving.[1]

The following *characteristics* are mentioned by Mollison[2] as *indicative of deep milking qualities* of Indian cattle :—(1) Mildness of temper. (2) Forequarters should be light in comparison with the hind-quarters which should be massive and heavy. (3) A good milch cow should have wide loins, deep, well-packed thighs with back ribs long and well sprung so as to give a large paunch and a full flank. (4) The *udder* should be of large capacity, the larger the better, provided it is not fleshy. It should not be too pendulous, but should extend well forward on the abdomen and should come up well behind between the thighs. (5) The *teats* should be large and of equal size. They should be squarely set on the udder and not grouped in a cluster. (6) The *milk vein* should be prominent. (7) A lean and clean cut head, a thin long neck, a thin long tail, and a soft and pliant skin are also other points observable in a good milker.

I have not been able to obtain complete information regarding all the different breeds of milch cattle in India. The breeds of buffaloes and cows described below are mostly those found in Bombay and Western India. A few well-known breeds from other parts have been also added. Most of the photographs of the Bombay animals were taken in my presence, the animals being selected from different cattle stables in Bombay. The selection of individual animals was made in consultation with the cattle owners and Mr. Laud, Veterinary Inspector. A few photographs (Saniwahl, Hansi, etc.) were kindly supplied by Mr. A. H. Spearman, Manager, Government Military Dairy, Kirkee, and a few others (Nellore, Mysore, etc.) by Mr. A. M. Paton, Manager,

[1] J. R. Blackwood, I. C. S., " A Survey and Census of the Cattle of Bengal," 1915, p. 13.
[2] Mollison's Text Book on Indian Agriculture, Vol. II.

Government Dairy Farm at Bangalore. The sources of other photographs are acknowledged elsewhere. The following breeds of buffaloes and cows will be very briefly described[1]:—

(*A*) *Buffaloes.*—1. Delhi or "Murrah." 2. Surati (Gujarati). 3. Jaffrabadi (Kathiawari). 4. Deccani. 5. Mehsana (Palanpur). 6. Varadi (Pandharpur).

(*B*) *Cows.*—1. Sindhi. 2. Gir (Kathiawari). 3. Saniwahl or Montgomery. 4. Hansi. 5. Kankreji. 6. Gujarati: (*a*) Surati, (*b*) other Gujarati breeds. 7. Deccani. 8. Nellore or Ongole. 9. Layalpur, (Punjab). 10. The Khillari Cattle. 11. The Mysore or "Amrit Mahal." 12. Malvi Cattle. 13. Krishna Valley Cattle. 14. Shahabad Cattle (Bihar). 15. Cross breeds: (*a*) Poona-Ayrshire and Sindhi. (*b*) Bankipur cross breeds.

(A) BUFFALOES.—(*vide* MAP.)

1. **Delhi** or "**Murrah.**"—(Plate I).

These buffaloes are bred in the Punjab, the United Provinces and Sindh. They are large in size with deep wide frames and short thick legs. They weigh from 1,000 to 1,200 lbs. The colour is usually jet black. Forehead is slightly prominent; face is hollow with staring looks, eyes small and active. *The horns are very characteristic,* being thick at the base and incline backwards and upwards, and then *curl up in two or three coils.* The ears are like the "Surati;" the body is massive and well developed and the udders are large. The daily average yield of milk varies from 18 to 27 pounds in Bombay, while the maximum yield of best animals in Northern India reaches up to 50 or 60 pounds. The average annual yield in Bombay is about 3,000 lbs. with a maximum of about 6,000 lbs. The manager of the Kirkee Military Dairy gives a record of 8,000 lbs. for one animal of this breed. The price of a good Delhi buffalo varies from Rs. 150 to Rs. 250 in Bombay.

2. **Surati.** (Gujarati or Nadiad)—(Plate II).

This is a medium-sized shapely breed, found in the northern and central parts of Gujarat. The colour varies a good deal. It may be black, grey, or albino. Forehead is flat, face narrow, eyes small and prominent; the horns are short and take a backward semi-circle, being slightly curved upwards at the tip; the

[1] The descriptions given here are mostly based upon information supplied by the Manager of Government Dairies in various parts of India, and by the Chief Veterinary Inspector Bombay.

hips are inclined upwards and inwards and the slope is on an equal level with the neck. Body is well formed and rounded, udders and teats are moderate in size. Being smaller in size than "Delhi" or "Jaffrabadi," they need less food. A Surati buffalo gives from 15 to 20 pounds of milk in Bombay. The maximum daily yield of best animals reaches 32 pounds. In Bombay, the average annual yield varies from 1,500 to 2,000 lbs., while the maximum seldom exceeds 3,000 lbs. In Poona, the average is from 2,000 to 2,500 lbs., while the maximum yield may reach 5,000 lbs. The price in Bombay of a good animal is from Rs. 100 to Rs. 125.

3. **Jaffrabadi.**—(Plate III).

These buffaloes are bred in the Gir Hills and throughout the south of Kathiawar. They are very large animals, being very ponderous in front, with prominent pelvic bones and rather long and thick legs. A full-grown female weighs from 1,600 to 1,800 lbs., while the male weighs from 2,000 lbs. upwards. The prevailing colour is black with a few white markings. Frontal bones are very prominent, giving a rounded appearance; below the eyes, face is narrow. The eyebrows are thick, eyes sunken and partially closed. The horns are thick and flat, having transverse ridges. They take a downward course at the root, then curve outwards, upwards and slightly backwards with a spiral twist. Body is very large, quarters large, udders deep and capacious, and milk veins prominent. Teats are long and contracted at the base, reaching sometimes below the hocks. The daily yield of milk in Bombay is from 20 to 30 pounds, while in Kathiawar the best animals are known to give 40 pounds. The average yield per year, in Bombay, is 4,000 lbs; when taken above the Ghauts, *e.g.*, in Poona, they give less milk. A good Jaffrabadi buffalo costs about Rs. 150 to Rs. 200 in Bombay.

4. **Deccani.**—(Plate XVIII).

This breed is indigenous throughout the Bombay Presidency south of the Tapti river. The face is small and flat; horns are short and thin, inclined upwards and backwards. Body and udders small in comparison to any other breed. The average daily yield is about 8 pounds, the maximum being about 12 lbs. The price varies from Rs. 70 to Rs. 100.

5. **Mehsana.** (Palanpur).—(Plate IV).

This breed is similar to "Surati" except that the size is slightly larger and the shape of the horns is different. The horns take a larger semi-circle at the middle and are not coiled as in the

"Delhi." Spacious udders and prominent milk veins are found in this breed. The price of a Mehsana buffalo is from Rs. 100 up.

6. **Varadi.** (Pandharpur).—(Plate XIX).

This is really a type of the "Deccani." Face flat and narrow similar to "Surati"; body like "Surati," but the horns are thin and very long, being inclined backwards and reaching frequently as far as the point of the hip. The Varadi buffaloes are generally sold from Rs. 60 to Rs. 75. The yield of milk is more than that of the "Deccani" type.

(B) COWS.

1. **Sindhi.**—(Plate V).

Most of these cattle are bred in the country adjoining Karachi and Haiderabad. They are smaller in size than the Gujarati cattle, the cows weighing 600 to 800 lbs. and bulls 900 to 1,100 lbs. Great care is taken to keep the breed pure. They have been selected for milking qualities for generations. Most of the "Sindhi" cattle have a deep red colour with occasional white spots or markings. The *wedge-shape* appearance is regarded as characteristic of a Sindhi cow, the hind-quarters being broad while the fore-quarters are narrow. The cows are mild in temper. Horns are coarse, blunt-pointed and take an upward and outward curve ; head is bigger than "Surati," neck is short and thick, pendulous dewlap and frame well developed. They are compactly built and have sloping shoulders and short legs. The hump is large, quarters flat and udders well developed. Sindhi cows are good milkers, giving as much as 30 lbs. milk per day in Sindh ; but in Bombay and the Deccan the yield is less, about 15 to 18 lbs. The average yield per year in Bombay varies from 1,800 to 2,700 lbs., the maximum being about 3,000 lbs. In Poona the average is about 2,000 lbs., while the maximum may reach up to nearly 5,000 lbs. The yield of these cows decreases in Bombay and the Konkan either on account of the excessive moisture or on account of the difference in the fodder.[2] The price of a cow in Sindh varies from Rs. 45 to Rs. 60. In Bombay it frequently costs double of this. The increase in price is partly due to exportation to Japan, South America, etc.

[1] J. B. Knight, M. Sc., and E. W. Horne, Bulletin No. 56 of 1913, Department of Agriculture. Bombay.

[2] Mr. Reeves, in a personal communication.

2. **Gir or Kathiawari.**—(Plate VI).

This noted breed derives its name from the Gir Hills and forests in the South of Kathiawar, which afford an excellent grazing ground all the year round. Gir cattle are remarkable for their purity of type and exhibit many characteristics by which they can be distinguished from all other Indian cattle. The colour is usually a mixture of red and white or black and white. The Gir cow is of medium size weighing 800 to 1,000 lbs. The udder is fairly capacious but fleshy, and the milk veins are prominent. The udder is pendulous and the quarters are drooping. There is an abundant loose skin under the neck and dewlap. The hump is of medium size. The *head, horns and ears are specially characteristic.* The *frontal bones* are well developed, which give a rounded appearance to the forehead. The horns take a backward curve and again incline a little forward. They are, as a rule, thinner and longer than those of bulls. The ears are long and pendulous. The muzzle is large and black. The eyes look sleepy and are shaded by heavy prominent brows. These cows are usually of an irritable temperament, and therefore the milk yielded is readily affected by any irregularity in feeding, in milking or general management. Under suitable conditions they give good milk. They do not thrive well in the dry plains, but for the Konkan they are probably the best breed of cows for dairy purposes. The demand for these cows in Bombay City is greater than that for any other breed. In Gujarat these cows give about 24 lbs. of milk, but in Bombay and the Deccan they yield from 12 to 16 lbs. per day. The average annual yield of milk in Bombay varies from 2,000 to 2,500 lbs., the maximum being about 3,700 lbs. The cow is not a persistent milker and gets dry sooner than the *Sindhi.* A Gir cow costs about Rs. 60 in Kathiawar and about Rs. 90 to Rs. 150 in Bombay.

3. **Saniwahl or Montgomery.**—(Plate VII).

The Saniwahl or Montgomery cattle are also known as the "Teli" breed. The cows are very superior milk producers; the only other Indian breeds that rival them in milk production are the "Hansi" and "Sindhi" cows. They are bred in the Montgomery District (Punjab) where vegetation is very scanty and rainfall is very light. They have been sent to many parts of India and apparently get acclimatized to conditions which differ greatly from those of the Montgomery District. They do not seem to flourish in Bombay and Poona. Montgomery cattle are described

as[1] "small, shapely and short legged, with fine clean cut heads, fairly short horns, small alert ears, thin necks, fine leg bones, small feet, and exceptionally long and thin tails." The long and heavy dewlap is characteristic. One of the main distinguishing features of the Saniwahl cow is considered to be the peculiar manner in which the horns are fixed, the short horns are set into the head very loosely and hang down so that they can be easily shaken at their bases. The udder is large and well shaped. The teats are also large and regularly placed. The colour of the skin varies a great deal—dark red, lemon and white, grey or spotted cattle being fairly common. The average daily yield of milk is from 15 to 20 lbs. The best cows are known to yield about 30 lbs. per day. The price of a good animal varies from Rs. 80 to Rs. 120 or even more.

4. **Hansi** or **Hansi-Hissar.**—(Plate VIII).

This is another leading breed of Indian cows. The Hansi cow comes from the Hansi-Hissar District. The yield of milk is affected a great deal by climatic conditions. Hansi cows will not prove as satisfactory in Jubbulpore (C.P.) as they will in Delhi or Meerut. It appears that the further they travel east or south, (that is, the damper the climate becomes,) the more certain is the decrease in the yield.[2] The average daily yield of a good Hansi cow varies from 20 to 30 lbs. If kept in their native habitat their milk production is equal to that of the Sindhi or Saniwahl breeds. A Hansi cow at the Allahabad Dairy Farm gave as much as 65 lbs. daily, and 7,000 lbs. during the lactation period.[3] This is probably a record for a cow of pure Indian breed. The prevailing colour is light grey. Red ones are occasionally found but are seldom good milkers. The head is clear cut with large expressive eyes, black muzzle, and upright curved horns sloping slightly backwards. The neck is moderately long and fine, carrying a fairly large dewlap. The head is always carried high, giving a very graceful appearance. In a good milker the shoulders and hump should be light with fine cut limbs. The barrel is long and round, and the milk vein prominent. The udder is usually compact and well set up under the flanks with moderately sized teats equidistant apart. The hind-quarters are usually straight and slightly higher than the fore-quarters. The tail is

1 Mollison and French : "Agriculture Journal of India," Vol. II, p. 252.
2 D. J. Meagher and R. E. Vaughan, "Dairy Farming in India," 1914, p. 44.
3 Ibid, p. 45.

long and moderately thick and carries a black brush. The most noticeable characteristic in the "Hansi" is its gracefulness. With head carried high and long measured gait it is probably the most graceful of the bovine tribe. The faults of the " Hansi " as a dairy animal are :—their inconsistency, irritability, and that they seldom do well outside of their own habitat.

5. **Kankreji.**—(Plate XIV).

They are bred mostly within the limits of the Palanpur Political Agency in Kankrej or Wadial. Some Kankreji cattle are bred in parts of the Ahmedabad and Kaira Districts. They are brought into the Gujarat and Baroda Territory by the dealers, so that they are really not indigenous to Gujarat. Kankreji cattle are considered to be the best cattle owned in Gujarat. The cows are generally silver grey or iron grey or white. They are large leggy animals weighing about 1,000 lbs. The bulls weigh from 1,200 to 1,500 lbs. Face is like " Surati," ears like "Jaffrabadi," head not prominent. Their horns are thin and take a spiral curve upwards and backwards and present a graceful appearance. They are rather nervous and excitable in disposition. Legs are long and thin, udders and teats not well developed. A good Kankreji cow costs in Bombay from Rs. 75 to Rs. 125. The yields recorded at Surat are about the same as the " Sindhis " at Poona.

6. **Gujarati:** (*a*) **Surati.**

Small and flat face, thin and well-shaped horns and frame well formed, ears small ; udders and teats not well developed.

(*b*) **Other Gujarati Breeds.**—(Plate IX).

The indigenous cattle found in the fertile plains of Ahmedabad, Kaira and Baroda are exceptionally fine and large. These breeds belong to Gujarat proper, and differ somewhat from Kankreji cattle. The horns are curved and pointed upwards with points turning inwards, little bigger than "Surati." The cows are generally poor milkers. The price varies from Rs. 70 to Rs. 90.

7. **Deccani.**—(Plate X).

The head is characteristic. The forehead is usually narrow above the eyes, which are prominent. The muzzle is large and black while the face has a narrow appearance. Body very small, thin and short ; horns take any shape ; thin and short legs, small hump, udders and teats small. The Deccani cows are very poor milkers giving only about 5 to 7 lbs. milk per day. The price is from Rs. 50 to Rs. 75.

8. **Nellore or Ongole.**—(*Plate XI*).

This breed of cattle is chiefly bred in the north-eastern districts of the Madras Presidency and forms the main milk breed of Madras. It does not conform uniformly to one type like many other Indian breeds. The variation in type and colour seem to indicate mixed breeding. The prevailing colour of Nellore cows is pure white. They are usually docile tempered. The body is somewhat narrow with a decided droop in the hind quarters. The head is typical, being long between the eyes with a large muzzle. The forehead bulges out above the eyes which are placed in elliptical sockets on the side of the head. The horns are short, thin and sharp, and incline backwards in a characteristic manner. The udders are not usually very well shaped and the teats are often close together in a cluster. The average daily yield of milk is about 15 lbs. The price varies from Rs. 50 to Rs. 150.

9. **Layalpur** (Punjab).

Face "Surati"; horns short and pointed upwards; ears long and broad. Body big and well developed; quarters well developed; short neck and straight back. They are very good milkers. The price varies from Rs. 100 to Rs. 125.

10. **The Khillari Cattle** are very poor milkers, but provide very fine bullocks. They are bred extensively in the Satpura Hills, chiefly in Holkar's Territory to the north of Khandesh, by *Khillaris* or *Dhangars* and *Vanjaris*. They resemble Mysore cattle in many respects.

11. **The Mysore Cattle.** The purest strain of Mysore cattle is the *Amrit-Mahal* (Plate XII) which occupies a very high position among the thorough-bred bullocks of India. The cows are very poor milkers.

12. **The Malvi Cattle** are bred in the territories of H. H. the Maharaja Sindia and H. H. the Maharaja Holkar. The cows seldom yield more than 4 to 6 lbs. of milk per day.

13. **Krishna Valley Cattle.**[1]—(Plate XV).

Cattle of this breed are met with in various parts of the Southern Maratha country and specially along the valley of the Krishna. They are large and well-built animals with white and grey as predominant colours. The general appearance of the animal is massive, heavy and lethargic. The cows are poor milkers, giving when in full milk about 6 lbs. in the whole day.

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[1] K. Hewlett, "Breeds of Indian Cattle," Bombay Presidency, 1912.

2

Good Krishna Valley cows are worth from Rs. 75 to Rs. 150. (10) (11), 12) and (13) are not important breeds with regard to milk production and hence a detailed description is not considered to be necessary.

14. **Shahabad Cattle.**—(Plate XVI).

The Shahabad district is bounded on the north by the Ganges, on the east and south by the Sone and the Mirzapur district, on the west by the Mirzapur and Ghazipur districts of the United Provinces. In the south of the district the Kaimur Hills afford good grazing during the rains, and cattle from long distances are driven thither in the month of June to remain in *bathans* until September or October. A large number of buffalo-cows are to be found here subsisting at this period entirely on grazing.

The prevailing colour of this strain is dark grey. The head is carried fairly erect, is long and tapers to the nose. The forehead is about 8 to 9 inches broad between the eyes and is slightly convex. The eyes are deep set and mild, surrounded by a rim of black tinged hair. The muffle is black. The horns are short, thick and blunt at the point, set somewhat erect to the head. The dewlap is of medium development. The neck is short and thick. The back rises a little towards the loins ; the quarters are sloping. The shoulders are well defined ; legs short with good bone and carried well apart. In the cows the udder is well developed with teats properly separated and the milk vein is distinctly prominent. The tail reaches just to, or a little below, the hocks ; the hoofs, like the horns, are black. The animal presents a well-bred appearance and a good cow is strikingly different from anything that can be seen in North Bihar. The price varies from Rs. 70 to Rs. 80. The average product is about three to four seers per day, while many cows can be found giving as much as 6 to 8 seers.

Many of the cows are sold to the Calcutta market for milking purposes and prices have risen considerably of recent years, while people complain that good cows are scarcer than they were, as is only natural, since all animals that go out of the district to Calcutta are lost for good since it does not pay to keep them there after the milking period is over, and they are either slaughtered or exported to Rangoon and the Straits Settlements also for slaughter.[1]

[1] This description as well as the photograph were kindly supplied by Mr. G. Milne, I.C.S., Director of Agriculture, Bihar and Orissa.

15. **Cross-breeds :**—(*a*) *Indian* cross-breeds, (*b*) Cross-breeds between *European and Indian* cattle.

(*a*) Apart from the distinctive breeds mentioned above and in the map, (q.v.) there are a number of cross-breeds to be found everywhere in India. For instance, in Gujarat, such cross-breeds usually show signs of Gir or Malvi blood, in the Deccan of Khillari or Gir blood, and in the Karnatak of Mysore blood.

(*b*) Plate XIII represents a half-bred cow from an Ayrshire bull and a Sindhi cow, bred at the Government Military Dairy Farm at Kirkee. The average annual yield is about 4,000 lbs., while the maximum yield may reach 10,000 lbs.

Cross-bred Bankipur Cattle or Tayler Breed.—The results of cross-breeding at Bankipur may be briefly stated. The hump characteristic of the Indian zebu is bred out. The females have improved greatly in milk-producing capacity, giving from 8 to 14 seers, but this is certainly an extravagant estimate, or at least is more than is now obtained by the *gowlees* from their present race of cows. On the other hand the male stock, although powerful animals, able in spite of the absence of the hump to draw heavy loads on good roads, are delicate and cannot stand the sun or labour in deep water and mud on the paddy fields. They are therefore not popular as draught animals. Another drawback is that they are much more susceptible to epidemic disease than the pure bred country cattle. This will remain the great danger of cross-breeding until such time as a cross is established that combines the disease-resisting qualities of the Indian zebu with the milking capacity of a European stock.[1]

The *amount of milk* yielded by Indian cows and buffaloes depends upon a variety of factors such as breed, the kind and amount of food, season, &c. *Breed* is perhaps the most important single factor. For instance, the "Delhi" and "Jaffrabadi" breeds of buffaloes yield a larger amount than the "Surati" and "Deccani" breeds. The following tables give the average yield of milk from various breeds of cows and buffaloes that are found in various parts of India. The factors which influence

[1] G. Milne, I.C.S., in a personal communication.

the yield of milk are so varied and numerous that it is not possible to lay down any accurate figures. The figures given below are only approximate :—

TABLE I.*

Breed of Animals.	Average yield of milk per year (in pounds.)	Maximum yield of milk of best animals per year (in pounds.)	Remarks.
Cows.			
Gir (Kathiawari) ..	1,500	2,500	The quantity at Morning and Evening milking depends entirely on the hour of milking. If regularly milked at 6 a.m. and 6 p.m. the quantity will be equal but not the quality.
Sindhi	2,500	6,000	
Gujrati (Kankreji) ..	2,000	3,000	
Deccani	750	1,200	
Saniwahl..	2,500	7,000	
Half-bred from Sind and Ayrshire	4,000	10,000	
Buffaloes.			
Delhi (Murrah)	3,000	10,000	
Surati	2,000	3,500	
Jaffrabadi	2,500	5,000	
Deccani	1,250	1,500	
Mehasana (Palanpur) ..	2,500	3,500	
Sindhi	2,000	4,000	

* This table was kindly supplied by Mr. G. H. Frost, Hony. Secretary, Dairy Education Association, Kirkee.

TABLE II.

Breed of Animals.	Average yield of milk per year.	Maximum per year.	Yield of milk per day of best animals. Average.	Yield of milk per day of best animals. Maximum.	Remarks.
Buffaloes.	Pounds.	Pounds.	Pounds.	Pounds.	
1. Delhi ..	2,970	5,250	18	27	These approximate calculations are based upon enquiries made by the Veterinary Inspectors from various *Gowlees* in Bombay, but the figures are liable to variations under certain conditions. The calculations are made on the basis of full quantity for the first three months in ordinary animals and every month a reduction of 2 pounds. In good milkers full quantity for four months and four pounds reduction every following month are allowed. One Bombay Seer=24 Ozs= 1½ lb.
2. Surati ..	1,620	2,160	12	15	
3. Jaffrabadi ..	4,050	5,400	22	30	
4. Deccani ..	1,100	1,350	8	12	
5. Mehasana (Palanpur) ..	2,970	3,570	18	21	
6. Varadi (Pandharpur) ..	1,080	1,620	10	16	
Cows.					
1. Sindhi ..	1,800	2,700	12	18	
2. Surati ..	1,080	1,620	9	12	
3. Deccani ..	650	1,050	6	9	
4. Gujarati (Kankreji) ..	1,180	1,595	9	11	
5. Gujarati (Pathan) ..	1,080	1,620	9	12	
6. Gir	2,250	3,645	15	22	
7. Kutchi ..	1,080	1,395	9	10	
8. Layalpur (Punjab) ..	1,620	2,160	12	15	

The kind of *food* has a great influence both on the quantity and quality of the milk produced. Animals fed on "Toor chuni," (husk of *Cajanus Indicus*), cotton seed, wheat bran, oil cakes and other similar foods yield better quality of milk than those fed on food deficient in proteids and fats (vide Chapter V). Green grass is found to increase the yield of milk, but at the expense of the quality. Succulent and green fodder lowers

the percentage of total solids, but it slightly increases the quantity of milk. It is a common belief among *Gowlees* and other milk producers in India that watering the animal just before milking increases the yield of milk, but this is not based on facts.

In dry and moderately hot *weather* cows seem to do best, while on the other hand, the rainy season suits the buffaloes admirably. Extremes of heat and cold cause a decrease in the amount of milk produced. The influence of weather and other conditions are fully discussed in Chapter V. The influence of *altitude* on the yield of milk has been observed in different places in India. It has been found that the maximum yield of milk is obtained on the *plains* from cattle in their own habitat. When the animals are removed to a higher elevation, *e.g.*, above the Ghauts or hills, the yield is known to drop down as much as twenty per cent.

THE MILK SUPPLY OF BOMBAY.

Almost all the milk supply of Indian cities is obtained from buffaloes and cows although a small amount is procured from goats, etc. It is estimated that in Bombay (with a population of 979,445 according to the census of 1911) there are about 21,000 milch cattle within the city limits, out of which about 18,000 are buffaloes, the remainder being cows. No statistics are available regarding the number of milch cattle in the suburban districts which supply milk to Bombay, but the number may be calculated as between 8,000 and 10,000. In Bombay the number of buffaloes far exceeds the number of cows. The buffalo is evidently found to be a much more profitable milking animal than the cow. According to a rough census taken in February, 1915, and again in August, 1915, it appears that the total amount of milk daily consumed in Bombay varies from 245,000 to 285,000 lbs., giving an average of 265,000 lbs., or about four thousand and four hundred Bombay maunds. Out of this, about 40,000 to 45,000 lbs. of milk are daily imported—the rest being produced within the city.

There are three main sources of the milk supply of Bombay:—

1. Within the City and Island of Bombay;
2. From the suburbs, most of which are situated on the Island of Salsette;

3. From distant places such as Poona, Kirkee, Ahmedabad, etc.

1. Milk is supplied **within the City of Bombay** in three ways :—(*a*) by the INDIVIDUAL MILK VENDOR OR GOWLEE, who usually hawks about from house to house distributing milk to his customers. The milk is generally contained in brass vessels of varying sizes which are either carried on the head or allowed to hang from a pole slung across the shoulders. (Vide Plates XXII and XXIII.) There are two or three kinds of "lotas" used—each "lota" containing milk of different quality and price. The larger lotas or vessels are usually covered only along the edges by a miniature wreath made out of hay picked up promiscuously from amongst the rubbish lying about the filthy stable. This is an additional source of pollution. Adulteration is very common except in the case of high-priced milk sold by a few honest *Gowlees*. As far as can be ascertained there are 1,548 individual "hawkers" of milk in Bombay.

(*b*) BY MILK SHOPS: "Halwais," (sweetmeat sellers), etc. These shops are numerous in the "native" part of the town. It is estimated that there are 837 milk shops in Bombay. Here also adulteration is almost the rule. Plates XXV and XXVI represent typical milk shops. The milk is kept here in open vessels exposed to the dust and dirt of the narrow streets and is handled in a very insanitary manner. A great deal of the milk in the "Halwai" shops is used for making sweetmeat (pedas, etc.), "Mawa" and "Basundi."

(*c*) BY THE DAIRIES. It is estimated that there are about 36 dairies in Bombay. The milk supplied by the majority of these dairies is by no means of a superior quality. Many of the dairies sell milk in special bottles or in closed milk cans which are locked and sealed. In spite of all these precautions it is found that only a few dairies can be depended upon to supply genuine and clean milk. Most of the so-called "dairies" in Bombay are no dairies at all, in the sense that they are understood in America and in Europe. The "Dairymen" usually are the agents or importers of milk. Very few of them own any milch cattle. They generally purchase milk from *Gowlees* (milkmen) at a fixed low price and then sell it to their customers at a high price. They thus act as "middle" men. There are very few genuine dairies in Bombay. The author has come across only four or five good dairies in Bombay, three of which (owned by Europeans) are

quite modern in their equipment and employ sanitary methods for the production and distribution of milk.

There are 86 licensed *milch cattle stables* containing about 15,068 milch cattle within the Municipal limits of Bombay. With a few exceptions, they are usually kept in a very insanitary state, (see Plates XXVIII, XXIX and XXX). In these stables milk is liable to get contaminated from numerous sources and in a variety of ways. It may be said, in general, that the majority of the milch cattle stables in Bombay, *including those belonging to many of the dairies,* need improvement in several respects. The vessels in which milk is drawn are by no means kept scrupulously clean. It is a rare thing to see either the udders of the animals or the hands of the milkman being thoroughly washed before milking. Besides, the water added for adulteration is usually unfit for drinking purposes, cow-dung being not an uncommon constituent of adulterated milk. The old stables are as a rule situated in very crowded localities. They are hardly ever thoroughly cleaned or flushed. The animals may often be seen wallowing in their excrement and in the stable refuse. The condition of some of these stables during the monsoon is most deplorable ; the rain and wind beat in mercilessly at times and the animals tethered there have to submit most meekly to all the vicissitudes of an inclement rainy weather. This type of stables, however, is now gradually disappearing and is being replaced by a better type as required by the new Bye-Laws of the Bombay Municipality.

2. From the Suburbs.

This is a very important source of the milk supply of Bombay. Most of these places are situated near one of the two railway lines (the G. I. P. and the B. B. & C. I.) The various suburban railway stations from which milk is imported into Bombay are Virar, Bassein, Nalla Sopara, Borivili, Andheri and Bandra on the B. B. & C. I. Railway, and Kalyan, Dombivili, Thana, Ghatkooper and Kurla on the G. I. P. Railway, the longest distance being 34 miles and the shortest distance about 10 miles. The total amount of milk imported daily at the various local railway stations in Bombay is estimated at about 45,000 pounds. The milk is usually conveyed in the local (suburban) railway trains in a most primitive and insanitary manner. There are no " milk trains " nor are there any special " milk cars ." The milkmen usually crowd into the ordinary third class compartment along with other

passengers, shelving their open milk cans under the dirty seats. The cans or vessels are covered only along the edges with concentric rings of straw, which is supposed to prevent the spilling of the milk. The filthy condition of an ordinary third class car, the dirt and dust flying into the open milk vessels and the insanitary habits of most of the passengers occupying a third class compartment can be more easily imagined than described. The milk has already been drawn under the most insanitary conditions, and, after a slow journey of two or three hours under the above conditions, arrives at its destination in Bombay and thence distributed to the public. The high temperature and moist atmosphere add further to the most favourable conditions for bacterial growth. According to a census taken recently there are at least 429 "importers" of milk in Bombay. It is estimated that about 1,500 men are employed for bringing milk daily to Bombay.

3. From distant places like Poona, Kirkee, Ahmedabad, Anand, Nadiad, etc.

The Government Military Dairy in Bombay get their milk supply daily from Kirkee and Ahmedabad. The milk is "pasteurised" at 170° F. for two minutes, rapidly cooled to nearly freezing point and kept there until it is taken by train. Insulated cans with cold packing outside are in use. There are no special milk cars at present, but the ordinary railway waggons are used. The journey from Kirkee to Bombay takes about four hours, while that from Ahmedabad to Bombay occupies about ten hours. On the former journey the temperature goes up about 10° F. and on the latter journey about 25° F. The milk cans are not kept at any constant temperature during their transit to Bombay. On arrival in Bombay, the milk is again pasteurised and cooled to a temperature of about 40° F. and then issued to the customers either in cans or in special bottles. The milk supply from Ahmedabad and Poona is about 2,200 pounds per day. Some milk is also brought from Gujarat daily by other dealers. A large dairying concern has been organised recently for importing large amounts of pasteurised milk from Nadiad and other places in Gujarat.

THE MILK SUPPLY OF CALCUTTA.

(Population 896,067.)

The milk supply of Calcutta is obtained from three sources: (*a*) from the adjoining country districts, (*b*) from the suburbs,

and (*c*) from the local cowsheds. The supply is in about equal proportions from the three sources. The conditions under which the milk is produced are insanitary and unsatisfactory, especially as regards the supply from outside sources.[1]

The number of milch cattle in Calcutta are as follows[2]:—

	Cows.	Buffaloes.
Local	10,771	133
Imported	4,167	926
Total ..	14,938	1,059

The number of cows greatly exceeds the number of buffaloes, in contrast to Bombay, where the buffaloes outnumber the cows. The total amount of milk consumed daily in Calcutta is estimated at about 3,000 maunds or 240,000 pounds. It appears that the price of milk has at least doubled within the last ten years and is likely to go up still further.[3] The whole of the milk consumed is more or less adulterated with water and is contaminated, owing to the unsatisfactory conditions under which milk is produced and handled.

THE MILK SUPPLY OF DELHI.

(Population 225,471.)

There are two main sources of the milk supply: (1) within the city, and (2) from Shahdra on the other side of the river Jumna. Most of the milk is brought in by hand by the *Ghosis*. The amount of milk daily consumed in Delhi is about 650 maunds or about 50,000 lbs., being supplied in about equal proportions from both the sources. There are 600 cows and 1,230 buffaloes in Delhi. The average yield for a good buffalo is about 20 lbs. per day, while a cow gives about 12 lbs. per day.[4]

The Health Officer of Delhi in his Annual Report for 1914 makes the following observations on the milk supply:—

" The conditions of the milk supply in Delhi are most unsatisfactory, and to this as one cause may be ascribed the high rate of

1 Report of the Health Officer of Calcutta for 1913, p. 43.
2 " A Survey and Census of the Cattle of Bengal," by J. R. Blackwood, LL B. I.C.S., Appendix I.
3 Ibid, pp. 27 and 28, by Blackwood, I.C.S.
4 Dr. K. S. Sethna, Health Officer, Delhi, in a personal communication.

infant mortality which has been noticed in an earlier portion of this report. The matter is indeed one which requires immediate attention and no words could be too strong to describe the present condition of affairs. There is in fact absolutely no control of any sort over this most important article of diet. Cattle are kept in the most insanitary conditions, crowded together in unlit, unventilated and undrained sheds; no care is taken of the receptacles for milk which are usually filthy and kept in filthy surroundings. Though want of a laboratory has prevented any samples being taken for analysis, it would not be rash to say that adulteration of milk is universal, and the quality of the milk also suffers from the existence of a European dairy which takes practically the whole of the cream. Such conditions not only imply a tainted milk supply but also constitute in themselves a menace to the general health of the city. Bye-laws for the proper regulation of cattle sheds are an urgent and crying need, but even more desirable from the point of view of the health of the cattle, and of the general health of the city, would it be to cause the greater part of the cattle to leave the city for more healthy surroundings, and efforts have been made during the past year to establish grazing settlements across the River Jumna."

THE MILK SUPPLY OF MADRAS.

(Population 518,660.)

Like Bombay and Poona, Madras has two main sources of milk supply: (1) within the city, and (2) from the adjoining villages. A third source is mentioned, namely,[1] *tinned milk* which is imported in large quantities into the Port of Madras.[2] It appears that there are only two real dairies in Madras. The milk business is mostly in the hands of petty cattle owners. 3,587 milch cattle are owned by 531 licensed cattle-keepers in the City! The condition of the cattle-sheds is described as being unsatisfactory in every way, "construction, entire space, ventilation and sanitation leaving much to be desired." Many of the sheds occupy either a part of human dwelling houses, or they are attached to these houses. The walls of these sheds are in every case plastered with cow-dung cakes. Overcrowding, low roofs,

[1] Appendix A of the Annual Report for 1913, of the Health Department, Corporation of Madras.

[2] In the year 1912-13, 720,181 lbs. of condensed milk were imported into Madras it is not known as to how much of this was actually used up in Madras City.

insufficient space, bad flooring, faulty provision for drainage, etc., are some of the common features of the cattle-sheds. The cattle are never washed and the udders and teats not cleaned before milking.

Conditions regarding storage and distribution of milk in the city are of the most primitive kind. There are no regular milk-shops as in Bombay. Milk is kept in cans and brass-vessels which are seldom washed. The vessels may or may not be covered; in the former case the cover used is a piece of dirty cloth. During distribution, the street milk-hawkers measure out the milk to the purchaser by means of a cocoanut shell dipped into the container along with their filthy fingers.[1] As regards the milk supply from the adjoining villages, it appears that about 2,400 lbs. of milk are daily brought into Madras by hand or in carts. All the insanitary conditions mentioned above with regard to the production and distribution of milk in the city are found even more intense in these villages.

THE MILK SUPPLY OF POONA.

(Population 117,256.)

In Poona the milk supply is obtained partly from the neighbouring villages and partly from within the city. It has been estimated that 21.25 per cent. of the total daily milk supply is obtained from the outside sources, 37.72 per cent. from animals kept by householders for their own use, and 40.63 per cent. from animals kept by *Gowlees* in the city itself. It appears that only 8.5 per cent. of the imported milk is provided by cows, the remainder by buffaloes. From an actual census taken, the number of milch cattle in Poona is given as 2,688 within the city and 956 in the neighbouring villages which supply milk to Poona, or a total of 3,644 animals in all. The total *daily* milk supply is estimated at 25,690 lbs.[2]

The milk from the surrounding villages is brought to Poona by hand, there being no special provisions for milk-wagons, etc. Adulteration with water is very common. The sheds for milch cattle in the city are described as being very insanitary. During a special investigation in Poona, it was found that the sheds were situated in all sorts of positions, without any control. "Nearly six per cent. were under a dwelling house, over six per cent. were

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[1] Annual Report of the Health Dept., Corporation of Madras, 1913.

[2] *The Supply of Milk to Indian Cities,* by Dr. H. H. Mann; *Journal of Dairying and Dairy Farming in India,* Vol. I, No. 1.

either *in* a dwelling house or on the verandah of a dwelling house ; over fifteen per cent. were attached to and continuous with a dwelling house, while sixty-three per cent. were in the compound of a dwelling house."

The milk supply of other large Indian cities is somewhat similar to that of Bombay, Madras, Poona, etc., with a few local differences which are of little or no importance. It is unnecessary therefore, to go into the details.

The following table gives a summary of the approximate number of milch cattle and the daily consumption of milk in some of the large Indian cities :—

[TABLE.

TABLE.

Table showing the existing sources and the daily supply of milk of a few typical Indian cities.

Name of the City.	Population (Census of 1911.)	Milk Supply per day.			Available supply per head of population.	Number of milch cattle in the city.		Authority.
		Within the city. (Pounds.)	From outside (Pounds.)	Total. (Pounds)		Buffaloes.	Cows.	
1. Bombay ..	979,445	220,000	45,000	265,000	0·27 lb.	18,000	3,000	Lemuel L. Joshi.[1]
2. Calcutta ..	896,067	?	?	240,000	0 26 lb.	1,059	14,938	J. R. Blackwood, I.C.S.
3. Madras ..	518,660	?	2,400(?)	Not known	....	2,340	1,248	Health Officer's Report for 1913.
4. Delhi ..	225,471	25,000	27,000	52,000	0·23 lb.	1,230	600	K. S. Sethna.
5. Ahmedabad...	172,579[2]	23,000	19,000	42,000	0·24 lb.	1,548	573	Bhimbhai Desai.
6. Poona ..	117,256	20,130	5,690	25,820	0·21 lb.	1 338	1,350	H. H. Mann.
7. Surat ..	114,868	12,000	30,000	42,000	0 36 lb.	1,000	250	Bhimbhai Desai.
8. Sholapur ..	95,000	13,500	about 100	13,600	0.13 lb.	....	....	Tagare.
9. Hubli ..	80,000	8,500	1,500	10,000	0·16 lb.	1,100	575	Kulkarni.

[1] Figures are approximate.
[2] This represents the population of Ahmedabad inside the city walls to whom milk is supplied.

CHAPTER III.

CHEMICAL COMPOSITION OF MILK OBTAINED FROM VARIOUS SOURCES.

PROPOSED MILK STANDARDS FOR INDIA AND THE EXTENT OF ADULTERATION IN INDIAN CITIES.

It is well known that the chemical composition of milk in India differs in many respects from that in Europe and in America. This is largely due to the fact that in India one has to deal with buffaloes' milk as well as cows'. The former shows a higher percentage of proteids and fat than the latter. Besides, the milk of the average Indian cow contains about one per cent. more fat than the milk of most European cows. Buffaloes' milk was first examined by F. Strohner[1] in 1888. In 1889, Simpson and Stevenson examined the milk of cows and buffaloes in Calcutta. Similar investigations were carried out at a later date by Dutta and Ghose of the Calcutta Municipality.[2] In 1890, Deppel and Richmond investigated the milk of the "Gamoose" in Egypt.[3] Buffaloes' and cows' milk in the Bombay and Madras Presidencies were examined by Leather in 1899 and 1900.[4] In 1907, buffaloes' milk was again examined by Leather in Poona[5] and this was follwed by Meggit and Mann in 1907-1908.[6] In the Bombay Municipal Laboratory, the chemical examination of milk dates back to 1903.

In the papers on milk read at the All-India Sanitary Conference in Lucknow in January 1914, by Dr. M. Shrinivasa Rau of Bangalore and by the author, the composition of milk in Bangalore and in Bombay, respectively, was discussed. Data from other parts of India either have not been published or are not available.

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1 F. Strohner: "Chemisches Centralblatt," 1888, p. 478.
2 W. J. R. Simpson: "The Principles of Hygiene," 1908, p. 181.
3 Journal of the Chemical Society, 1890, p. 754.
4 W. J R. Simpson: "The Principles of Hygiene," 1908, p. 182.
5 J. Walter Leather: "The Analyst," Vol. XXVI. (1907), p. 40.
6 A. A. Meggitt and H. H. Mann: "Memoirs of the Department of Agriculture in India." Vol. II, Nos. 1 and 4.

Complete analysis of Indian Buffaloes' Milk.

TABLE A.

	Number of Samples.	Specific gravity at 15.5° C. (60° F.)	Non-fatty solids %	Water %	Fat %	Proteids %	Lactose %	Mineral Matter %	Remarks.
1. Bombay									
Lemeul L. Joshi									In Series A the fat was determined by Adams' method and in Series B by Gerber's method.
Series A. ..	50	1.0315	9.5	82.3	8.2	4.0	4.4	0.8	
Series B. ..	50	1.0308	9.8	81.6	8.6	3.89	4.52	0.78	
(*Vide* Table B.)									
2. Poona (Kirkee,)									Fat by Gerber's method.
J. Walter Leather ..	..	1.0321	9.69	82.22	8.09	4.34	4.56	0.76	
3. Bangalore									
Shrinivasa Rau ..	129	1.026	8.8	85.13	6.07	3.92	4.13	0.75	Fat by the Werner-Schmidt method.

The following analytical figures were recently obtained by me from fifty genuine samples of Buffalo-milk (various breeds) in Bombay :—

TABLE B.

No.	Specific Gravity at 60° F.	Total Solids % (by Actual Weighing.)	Fat % (Gerber's.	Non-fatty Solids %	Proteids % Kjeldahl's Method.	Lactose %
1	1032	15.92	6.5	9.42	3.83	4.29
2	1030	13.82	5.0	8.82	3.37	4.15
3	1030	18.83	9.3	9.53	3.93	4.30
4	1032	14.38	5.4	8.98	3.72	4.06
5 (s)	1029	19.70	9.2	10.50	3.78	5.02
6	1031	19.70	10.0	9.70	3.42	4.98
7	1029	19.92	10.5	9.42	4.19	4.03
8	1031	20.44	10.5	9.94	4.51	4.15
9 (s)	1029	21.30	10.0	11.30	4.15	5.35
10	1027	17.82	9.4	8.42	3.50	4.12
11	1027	19.10	10.0	9.10	3.59	4.21
12	1033	19.62	10.2	9.42	4.85	3.77
13	1031	18.40	9.0	9.40	4.10	4.50
14	1030	18.31	9.2	9.11	3.49	4.32
15	1031	18.62	8.9	9.72	3.55	4.87
16 (s)	1030	21.31	11.4	9.91	3.86	4.75
17 (s)	1030	20.13	9.6	10.53	3.81	5.42
18 (s)	1035	19.22	8.8	10.42	3.89	5.23
19 (s)	1033	20.84	9.9	10.94	4.00	5.25
20 (s)	1034	21.16	10.5	10.66	3.97	5.09
21 (s)	1030	19.46	9.3	10.16	3.85	5.01
22 (s)	1031	19.41	9.5	9.91	3.98	5.33
23	1032	16.72	6.8	9.92	3.90	4.22
24	1033	17.28	7.5	9.78	3.85	4.63
25	1033	16.10	6.6	9.50	3.63	4.57
26	1031	19.12	9.3	9.82	3.98	4.54
27	1032	15.58	5.9	9.68	3.84	4.54
28 (s)	1031	19.26	9.0	10.26	4.00	4.96
29	1033	16.24	6.5	9.74	3.85	4.59
30	1029	20.52	11.0	9.52	3.75	4.47
31	1031	16.68	7.1	9.58	3.93	4.35
32 (s)	1030	21.08	10.5	10.58	4.18	5.10
33	1032	16.31	7.2	9.11	3.70	4.11
34	1029	20.10	10.5	9.60	4.10	4. 2
35	1030	16.71	7.5	9.21	3.58	4.33
36	1029	20.54	11.0	9.54	4.19	4.05
37	1035	15.26	6.3	8.97	4.02	4.15
38	1032	19.20	9.8	9.40	4.10	4.50
39	1031	15.77	6.5	9.27	3.76	4.21
40 (s)	1032	19.06	9.0	10.06	3.92	4.84
41	1033	14.68	5.2	9.48	3.84	4.34
42	1031	19.30	10.2	9.10	4.10	4. 2
43	1031	8.62	8.9	9.72	3.93	4.49
44	1030	19.22	9.5	9.72	4.10	4.32
45	1032	17.18	7.7	9.42	3.75	4.43
46	1028.5	21.10	11.6	9.50	4.10	4. 1
47	1029	18.38	8.8	9.58	3.66	4.62
48	1029	20.50	11.0	9.50	4.17	4.28
49	1031	17.20	7.6	9.60	3.85	4.45
50	1030	19.06	9.3	9.76	3.92	4.54
Average of 50 Samples.	1030.8	18.40	8.6	9.8	3.89	4.52

(*s*) Samples marked (*s*) were from the "Surrati" breed of buffaloes.

Meggit and Mann give the following figures for complete analysis of *mixed* milk of the whole Poona Dairy herd :—

	I Sept. 26th, 1907.	II Oct. 3, 1907.	III Oct. 10, 1907.	IV Oct. 17, 1907.	V Oct. 24th, 1907.	VI Nov. 7th, 1907.	VII Nov. 14, 1907.
Water %	81·5	82·21	82·1	81·72	81.94	81·19	81·43
Fat %	8·05	7·60	8·0	8·15	7·90	8·70	8·40
Proteids %	4·33	4·27	4·31	4·35	4·30	4·37	4·36
Milk-Sugar %	5·28	5·09	4·74	4·97	5·03	4·91	5·02
Ash %	0·83	0·83	0·85	0·81	0·83	0·83	0·79
	100·00	100·0	100·0	100·0	100·0	100·0	100·0
Total Solids %	18·49	17·79	17·90	18·28	18·06	18·81	18·57
Non-Fatty Solids %	10·44	10·19	9·90	10·13	10·16	10·11	10·17
Sp. grav: at 60°F	1031·6	....	1031	1031·5	1031·5	1031·5	....

The analytical methods used in these calculations were different with different observers. In Poona, milk fat was determined by Gerber's method; in Bombay, Adams' process (with Soxhlet's apparatus) was used for fat in Series A and Gerber's method in Series B, and the total solids were always determined by actual weighing, etc. In Bangalore, the Werner-Schmidt process was employed for the estimation of fat.

For a routine examination of milk, the only constituents that need to be estimated are *Specific Gravity* (usually at 15·5° C or 60° F), *Fat* and *Total Solids*, the "*Non-fatty Solids*" being obtained by deducting the figures for *Fat* from *Total Solids*. Great variations have been found depending on various factors, such as age and breed of the animal, the kind of feed, time of calving, season, etc. These will be discussed in Chapter V.

The analytical results obtained in the Bombay Municipal Laboratory are given below in two series. In the first series (Table C) 271 samples of "Genuine" buffalo milk were examined from time to time. The fat was determined by Adams' process. In the second series (the most recent) 110 samples of genuine buffalo milk were examined from July 1913 to December 1914. Fat was estimated by Gerber's method.

TABLE C.—(Series I).

Average composition of "Genuine" buffalo milk in Bombay. Analyses of 271 samples.

1903-1909.	No. of samples examined.	Specific Gravity at 60o F.	Total Solids %	Fat %	Non-fatty Solids %
January	31	1029·41	17·76	8·21	9·55
February	30	1029·79	17·35	7·7	9·65
March	9	1028·83	16·94	7·11	9·83
April	20	1029·06	17·37	7·57	9·80
May	26	1029·36	16·96	8·15	8·81
June	22	1028·63	17·45	7·81	9·64
July	33	1028·58	17·50	7·64	9·86
August	30	1027·41	17·73	8·06	9·67
September	13	1028·18	16·75	7·33	9·42
October	17	1028·07	17·04	7·41	9·63
November	24	1029·30	16·57	7·26	9·31
December	16	1029·77	16·94	7·22	9·72
Total ..	271	1028·86	17·11	7·62	9·57

TABLE D.—(Series II).

Average composition of "Genuine" buffalo milk in Bombay. Analyses of 205 samples.

Date.	No. of Samples examined.	Specific Gravity at 60° F.	Total Solids %	Fat %	Non-fatty Solids %	Remarks.
July 1913.	11	1.027	17.94	7.71	10.22	The highest amount of fat found in these samples was 11 per cent. and the lowest was 5.2 %. The highest figure for "non-fatty solids" was found to be 11.36 per cent. while the lowest was 8.56%.
August „	8	1.030	18.20	8.42	9.78	
September „	1	1.029	18.26	9.1	9.16	
October „	5	1.029	17.57	8.26	9.31	
November „	10	1.030	17.48	7.94	9.54	
December „	15	1.031	17.36	7.85	9.51	
January 1914.	14	1.031	18.21	8.45	9.76	
February „	6	1.026	16.78	7.31	9.47	
March „	12	1.029	16.35	6.68	9.67	
April „	16	1.030	17.9	8.00	9.9.	
May „	2	1.030	18.76	8.5	10.26	
June „	5	1.029	17.93	8.32	9.61	
July „	11	1.030	16.8	7.4	9.4	
August „	10	1.029	17.38	8.3	9.35	
September „	28	1.029	17.64	8.23	9.41	
October „	15	1.029	17.61	8.27	9.34	
November „	14	1.030	16.85	7.67	9.18	
December „	22	1.030	16.67	7.3	9.37	
Total ..	205	1.030	17.40	7.87	9.53	

The samples were mostly collected at random from different dairies, cattle stables and individual milk vendors. They were taken from various breeds of buffaloes including Delhi, Surati, Jaffrabadi, Deccani, and Mehsana. Most of the samples represent "mixed" milk from different animals.

The average figures for "mixed" buffaloes' milk in Bombay as judged from the analyses of 271 genuine samples of Series I are 7.62 per cent. of fat and 9.57 per cent. of non-fatty solids. In Poona, from the analyses of 155 samples the percentage of fat was found to vary from 7.06 to 7.92 for "morning" and "evening" milk, respectively. In the Second Series of milk analyses comprising 205 samples, I found the figure for fat in the milk of two or three buffaloes to be as low as 5.2 per cent.; but never below that point under normal conditions. The average fat in the Second Series was found to be 7.87 per cent., and the highest figure for fat was over 11 per cent. in two samples. The non-fatty solids were found to vary from 9 to 10 per cent. in both series but rarely below 9 per cent. In two or three cases the non-fatty solids were 8.7 per cent., and in one case they were 8.56 per cent.

The average Specific Gravity at 60° F. in samples of the First Series was 1.0288, and in samples of the Second Series it was 1.030.

The following analytical figures are from fifty samples of cows' milk, most of which were collected by the Chief Veterinary Inspector of Bombay and his staff and certified to be "genuine." They were examined at the Municipal Laboratory with the results given below :—

TABLE E.

Average composition of "Genuine" Cows' Milk in Bombay. Analyses of Fifty samples.

1913-1914.	No. of samples examined.	Specific gravity at 60° F.	Total Solids %	Fat %	Non-fatty solids %	Remarks.
June 1913 ..	5	1·027	15·05	5·52	9·53	These samples were obtained from different breeds of cows including Sindhi, Gir, Surati, etc. The same analytical methods were used as in the case of buffalo milk.
July " ..	2	1·030	17·22	7·75	9·47	
August " ..	8	1·032	14·13	5·23	8·90	
Sept. " ..	12	1·030	15·29	6·33	8·96	
April 1914 ..	3	1·030	13·1	4·4	8·7	
May " ..	18	1·030	14·35	5·39	8·96	
July " ..	2	1·030	15·10	5·95	9·15	
Total. ..	50	1·029	14·89	5·79	9·10	

The percentage of fat was found to vary between 3.5, and 6, the average of fifty samples being 5.7, and only in one case it was found to be as low as 3. The average percentage of fat in 156 samples of cows' milk in Poona was found to vary from 4.52 to 5.34 for morning and evening milk, respectively.

The average composition of milk from 58 cows of Mysore Breed is given as follows by Dr. Shrinivasa Rau of Bangalore:—

Specific gravity.	Total Solids.	Ash.	Fat.	Proteids.	Lactose.	Water.
1027	13·11%	0·69%	4·58%	3·81%	4·03%	86·89%

In Bangalore, fat was found to be 4.58 per cent. in 58 samples. It is rare to find fat below 3.5 per cent. in genuine cows' milk in Bombay and Western India. The non-fatty solids ranged from 8.5 per cent. to 9.5 per cent., the average being 9.1 per cent. In very rare cases the percentage may sometimes fall below 8.5, which may be taken generally as the lowest limit.

Milk in Calcutta has the following average composition [1] :—

	Buffaloes' Milk.	Cows' Milk.
Water %	81·5	86·23
Total solids %	18·7	12·84
Fat %	8·57	3·34
Non-fatty solids %	10·75	9·1
Proteids (Casein) %	4·66	4·4
Sugar %	4·86	4·4
Ash %	0·74	0·75

[1] These figures were obtained by Dutta and Ghose, *vi* Simpson's "Principles of Hygiene" 1908. p. 181

The composition of milk in Lucknow, U.P., is given as follows [1] :—

	Buffaloes' Milk.	Cows' Milk.
Specific gravity at 15·5° C. ..	1·0309	1·0302
Fat %	7·29	5·48
Total solids %	16·43	14·26
Ash %	0·74	0·70

Breed.—The question of breed and its importance have been already mentioned in Chapter II. From the tables on pages 20 and 21 it will be seen that in the case of buffaloes the *largest yield* of milk is from the *Delhi* and *Jaffrabadi* breeds. Milk from *Surati* buffaloes has been generally found to be much *richer in fat* than any other milk, yielding nearly one per cent. more fat than the other breeds of buffaloes. In the case of cows, the *largest amount of milk* is given by *half-bred cows* from Sindhi and Ayrshire breeds, the next in order being *Saniwahl, Hansi* and *Sindhi.* As regards *richness in fat,* the Indian cows' milk usually contains a higher amount of fat than the milk of most European and American cows. The percentage of fat in *Sindhi* cows has been found to vary from 5.0 to 6.5, that in *Gir* cows from 5.0 to 6.0, while in the *Saniwahl* breed the amount of fat yielded varies from 3.5 per cent. to 5 per cent.

[1] Mr. MacMahon's paper at the All-India Sanitary Conference in Lucknow, quoted page 204, "The Journal of Dairying and Dairy Farming in India," Vol. I Part 3.

[TABLE.

TABLE F.

Summary of the average composition of milk from various breeds of cows in India.

No. of samples examined.	Name of breed.	Sp. gr. at 60° F.	Total Solids %	Ash %	Fat %	Proteids %	Lactose %	Water %	Authority.
58	Mysore	1027	13·11	·69	4·58	3·81	4·03	86·89	S. Rau, Bangalore.
9	Ajmer	1028	12·55	·72	4·16	3·64	4·03	87·45	
27	Baroda	1028	12·44	·7	4·02	3·69	4·03	87·56	
21	Delhi	1025	12·95	·69	3·51	(?)	4·24	87·05	
15	English bred cows in Bangalore ..	1027	13·44	·75	4·89	3·79	4·01	86·56	
15	Nellore & Ongole.	1027	12·79	·72	4·47	3·49	4·11	87·21	
11	Saniwahl.. ..	1024	13·08	·69	4·97	3·38	4·04	86·92	
						Non-fatty Solids %			
463	Sindhi (morning).		15·26		5·83	9·43			H. H. Mann, Poona.
466	Sindhi (evening)..		15·59		6·17	9·42			
175	Gir (morning) ..		14·34		5·41	8·93			
184	Gir (evening) ..		15·04		6·12	8·92			
12	"Jaffrabadi" (Gir)	1032·1	14·94		6·1	9·72		85·06	L. L. Joshi, Bombay.
5	Surati	1028·8	14·91		5·38	9·39		85·09	
Average of 134 animals.	Saniwahl.. ..	1031·9	14·0 (morning) 13·7 (evening)		4·65				Manager, Govt. Military Dairy, Peshawar.

TABLE G.

Chemical composition of milk from buffaloes of different breeds.

Name of breed	Total number of samples examined.		Total Solids.		Fat.		Non-fatty Solids.		Authority.
	Morning.	Evening.	Morning %	Evening %	Morning %	Evening %	Morning %	Evening %	
Surati	454	478	18·5	18·9	8·16	8·6	10·34	10·3	H. H. Mann, Poona.
Jaffrabadi	38	44	17·4	17·25	7·2	7·4	10·2	9·85	H. H. Mann, Poona.
Deccani	89	89	17·8	18·1	7·3	7·6	10·5	10·5	H. H. Mann, Poona.
Delhi	43	7	17·4	16·7	7·3	6·47	10·1	10·23	H. H. Mann, Poona.
Delhi	Average of 75 animals ..		16·6	15·9	6·8	6·4	9·8	9·5	The Manager, Govt. Military Dairy, Peshawar.

MILK STANDARDS FOR INDIA.

From what has been said above regarding the difference in composition between milk in India and milk in Europe or in America, it is quite evident that European or American standards for milk cannot hold good for India. The milk standard would be somewhat different in the different provinces of India, according to various climatic and other local conditions, which are mentioned at length in Chapter V. One uniform standard for all India may be very desirable, but in the absence of more data regarding the composition of milk in other cities and provinces, this does not appear to be quite feasible, at least at present. In any case, it would be best to have *local milk standards* for different parts of India, where similar conditions of climate, breed, fodder, etc., prevail. These local standards should not be fixed arbitrarily once for all, but they should be considered as only *provisional*, subject to modification if necessary. For purposes of legislation it would be necessary to *legalise* such standards at least as a tentative measure. In arriving at any standard, due consideration must be given to all the various factors which are likely to influence the composition of milk.

In the foregoing pages (vide Tables A to G) the average general composition of milk in Bombay, Poona, Bangalore, Calcutta, Lucknow, Peshawar, etc., is mentioned. Variations in composition of Indian milk due to many factors, *e.g.*, weather conditions, breed, food, disease, etc., have been studied only in the case of milk in Bombay and in Poona, and these will be discussed at length in a separate chapter. All these factors have been taken into consideration while proposing the following Chemical Standard for milk in Bombay and Western India. This standard is based on the analytical results of about four hundred samples of genuine milk obtained from different breeds of animals and collected in Bombay under the most varying conditions, from dairies, milk-shops, milch cattle stables, individual vendors, etc.

Proposed Milk Standard (Chemical) for Bombay and Western India.

	Fat, per cent.		Non-fatty solids, per cent.	
	Average.	Lowest limit.	Average.	Lowest limit.
Buffaloes' Milk	6·5 to 8	5·5	9 to 10·0	9·0
Cows' Milk	4 to 5	3·5	8·5 to 9·0	8·5
"Mixed" Milk	6·0	5·0	9·0	8·5

The "lowest limits" proposed are really very low, but these limits may be expected sometimes under certain influences, *e.g.*, breed, food, climate, etc., and also in the case of samples taken from individual animals, (vide Chapter V). Otherwise, in a milk sample from several animals the above "averages" are usually found. In good buffaloes' milk the average fat very seldom falls below 6 per cent., 7 to 8 per cent. being quite common, and the average non-fatty solids in most cases are found to be well above 9 per cent., although in a few genuine samples of buffaloes' milk I have known them to vary from 8.5 to 9 per cent. A genuine sample of cows' milk in Bombay usually yields from 4 to 5 per cent. of fat and from 8.5 to 9 per cent. of non-fatty solids. In many cases, however, the percentage of fat is found to be about 3.5 and in very rare cases, under certain conditions, this may fall lower down to even 3.0 per cent. The non-fatty solids are also sometimes known to fall a little below 8.5 in the milk of some individual cows, but this is extremely rare in market milk. Hence, the lowest limit for legal purposes may be fixed at 8.5 per cent.

Although separate standards for cows' milk and buffaloes' milk are necessary from a scientific point of view, many practical difficulties may arise if such standards were legalised. In the first place, it would seem almost impossible to expect the ordinary Indian milk dealers to declare honestly whether their milk is buffaloes' or cows'. Secondly, no analyst can distinguish between buffaloes' milk and cows' milk as such. It would be therefore easy for the vendor to remove some of the cream from buffaloes' milk and bring the fat down to the lowest limit allowed for cows' milk and sell it as cows' milk. Thirdly, it must be remembered that, as a rule, buffaloes' milk and a small amount of *mixed* milk (cows' and buffaloes') are sold in the local market, and no practical advantage would be gained by fixing separate standards for buffaloes' and cows' milk, unless a legal provision could be made that no mixed milk (cows' and buffaloes') shall be sold by any vendor or dealer, or that the proportion of one to the other shall be declared by the vendor or dealer at the time of sale. Considering the fact that the bulk of the public milk supply of most cities in the Bombay Presidency is obtained from buffaloes and that practically all the milk sold in the market is either mixed milk or buffaloes' milk, I am inclined to suggest ***one uniform standard for all milk*** sold in the market—namely, 5 ***per cent. fat and***

8.5 *per cent. non-fatty solids,* with the provision, that in the case of pure cows' milk when the source can be unquestionably proved, the fat standard may be allowed up to 3.5 per cent. Such a standard, if legalised, is likely to work well, at least so far as Bombay and Western India are concerned. As regards *fat,* many *mixed* samples that have been declared genuine by the vendors have been examined by me from time to time in Bombay and in not a single instance did the percentage of fat fall below five. A very large amount of mixed milk is daily purchased by the Government Central Creamery at Ahmedabad Cantonment from milk dealers. The milk is obtained from mixed herds of cows and buffaloes and no difficulty is experienced in getting an average of 5 per cent. fat in enormously large quantities (millions of pounds per year) of milk.

The Government Military Dairy in Bombay gets its daily supply of milk from Ahmedabad and Poona to the extent of over two thousand pounds per day. Milk is obtained from herds of cows and buffaloes and the samples taken from this source are of mixed milk. One hundred and thirty such samples were collected and examined by me with the following results :—

Average of 130 samples of mixed milk imported from Poona and Ahmedabad.

Specific gravity at 60° F.	Total Solids.	Fat.	Non-fatty Solids.
1.029	14.43%	5.9%	8.53%

In other words, the average percentage of fat in the mixed samples of "genuine" milk from a known source was found to be 5.9 or nearly 6, while the average of non-fatty solids was 8.5. There would be thus no difficulty in attaining the proposed uniform standard for mixed milk in Bombay, Poona, and Ahmedabad, *viz.,* five per cent. of fat and eight and a-half per cent. of non-fatty solids.

The removal of cream from milk is not practised so extensively by the Indian milk dealer as the adulteration of milk with water, etc. The latter practice, as will be shown later, is of great importance from a public health point of view. The amount of "extraneous" or "added" water is usually estimated on the basis of *non-fatty solids* in the milk sample. There is very little difference between the non-fatty solids in buffaloes' milk and cows' milk ; and for the mixed market milk, the lower limit

of 8.5 per cent. non-fatty solids is proposed. Any sample of milk which is found to contain non-fatty solids below this may be generally looked upon as being adulterated with water. This standard has been confirmed by many experiments. Several samples of genuine milk were adulterated with measured amounts of water in the Laboratory and then analysed. The calculated amount of "added" water on the basis of 8.5 per cent. non-fatty solids was found to be about the same as the amounts added originally. Very exceptionally, however, in the case of unmixed milk taken from individual cows, the non-fatty solids may fall to even 8.0, per cent., but this has never been found in the samples of cows' milk obtained by us in Bombay.

The one uniform milk standard proposed to be legalised for Bombay and other cities in Western India may be now stated as follows :—

Milk, as is ordinarily obtained in the market, shall be considered genuine if it is found to contain at least five per cent. of fat and not less than eight and a half per cent. of non-fatty solids; provided that the percentage of fat may be allowed up to three and a-half, only when it is proved to the satisfaction of the court that the sample was one of unmixed cows' milk, the onus of the proof resting with the vendor.

ADULTERATION OF MILK IN INDIAN CITIES.

It is a notorious fact that the extent of adulteration of milk in Indian cities is far in excess of that in European or American cities. Out of a total of 1,363 samples of milk examined at the Bombay Municipal Laboratory, during a period of five years, only 282 were found to be genuine. This gives 1,081 or 79.3 per cent. for *adulterated* or watered samples of milk in Bombay. The amount of water added varies from 5 per cent. to 80 per cent.

Statement giving a summary of the percentage of "added" or "extraneous" water in 118 samples of adulterated milk in Bombay:—

Above	50 per cent.	in	14 Samples	or	11·9 per cent.
Between 40 and 50	,, ,,	,,	13 ,,	or	11·0 ,,
,, 30 and 40	,, ,,	,,	25 ,,	or	21·2 ,,
,, 20 and 30	,, ,,	,,	28 ,,	or	23·7 ,,
,, 15 and 20	,, ,,	,,	24 ,,	or	20·3 ,,
,, 10 and 15	,, ,,	,,	9 ,,	or	7·6 ,,
,, 5 and 10	,, ,,	,,	5 ,,	or	4·2 ,,

(Vide also Tables J. and L.)

In Poona 80 per cent. of the milk was found to be adulterated with water. The amount of adulteration in Poona City is as follows[1] :—

Rate per Rupee.	Per cent. adulterated with water.	Average amount of water added to 100 parts of genuine milk.	Remarks.
1. 8 pounds. ..	None	....	All genuine.
2. 10 ,, ..	64	29 parts	
3. 12-14 ,, ..	50	47 ,,	
4. 16-18 ,, ..	92	72 ,,	
5. 20 & over ,, ..	100	117 ,,	

In Bangalore Dr. Shrinivasa Rau found 78 per cent. adulteration in buffaloes' milk. Out of 51 samples obtained from various parts of Bangalore City, 40 samples were found to be adulterated with water, the amount of "added" water ranging from 35 to 65 per cent.

In Calcutta the amount of adulteration with water varies from 5 to 80 per cent.

19 per cent. of the samples contained less than 10 per cent. of adulteration.

62.4 per cent. of the samples contained from 10 to 25 per cent. of adulteration.

16.1 per cent. of the samples contained from 26 to 50 per cent. of adulteration.

2.5 per cent. of the samples contained over 50 per cent. of adulteration.

In Lahore the amount of "added" water calculated on the basis of 8.5 per cent. of non-fatty solids varies from 30 to 40 per cent. and even higher. In Madras and in Delhi adulteration is reported to be very common, but no statistics are available regarding the amount of adulteration.

The following tables show the extent of adulteration of milk with water in Bombay and its relation to the price charged. Only the most recent figures are given :—

[1] This statement is based upon Dr. Mann's article in the "Journal of Dairying and Dairy Farming in India," Vol. I, No. 1.

46 Adulteration of Bombay Milk with water, showing the amount of water added and the price charged.—TABLE J.

Serial No,	Percentage of water added.	Price	
		Annas per seer (Bombay) 24 oz.	Per Quart.
1	9.3	3	5 d. or 10 Cts.
2	44.2	2½	4⅙d. ,, 8⅓ ,,
3	32.4	2	3⅓d. ,, 6⅔ ,,
4	45.8	2	3⅓d. ,, 6⅔ ,,
5	26.7	2	3⅓d. ,, 6⅔ ,,
6	18.0	3	5 d. ,, 10 ,,
7	26.0	3	5 d. . 10 ,,
8	9.0	3	5 d. ,, 10 ,,
9	16.4	3	5 d. ,, 10 ,,
10	28.2	3	5 d. ,, 10 ,,
11	20.0	3	5 d. ,, 10 ,,
12	17.8	3	5 d. 10 ,,
13	36.4	2½	4⅙d. ,, 8⅓ ,,
14	45.0	2	3⅓d. ,, 6⅔ ,,
15	6.0	3	5 d. ,, 10 ,,
16	25.8	2½	4⅙d. ,, 8⅓ ,,
17	11.4	3	5 d. ,, 10 ,,
18	21.5	4	6⅔d. ,, 13⅓ ,,
19	27.3	3	5 d. ,, 10 ,,
20	27.0	3	5 d. ,, 10 ,,
21	37.1	2½	4⅙d. ,, 8⅓ ,,
22	44.5	3	5 d. ,, 10 ,,
23	23.1	3	5 d. ,, 10 ,,
24	20.5	3	5 d. ,, 10 ,,
25	28.5	2½	4⅙d. ,, 8⅓ ,,
26	51.8	3	5 d. ,, 10 ,,
27	16.6	3	5 d. ,, 10 ,,
28	16.5	3	5 d. ,, 10 ,,
29	36.5	2½	4⅙d. ,, 8⅓ ,,
30	60.0	2½	4⅙d. ,, 8⅓ ,,
31	30.0	3	5 d. , 10 ,,
32	44.8	2	3 d. ,, 6 ,,
33	39.7	2½	4⅙d. ,, 8⅓ ,,
34	33.3	3½	5 d. ,, 11 ,,
35	17.7	2½	4⅙d. ,, 8⅓ ,,
36	21.3	2½	4⅙d. , 8⅓ ,,
37	46.0	2	3⅓d. ,, 6⅔ ,,
38	22.0	4	6⅔d. ,, 13⅓ ,,
39	31.8	2½	4⅙d. ,, 8⅓ ,,
40	58.0	2½	4⅙d. ,, 8⅓ ,,
41	38.5	3	5 d. ,, 10 ,,
42	16.6	3	5 d. ,, 10 ,,
43	32.8	3	5 d. ,, 10 ,,
44	15.22	2½	4⅙d. ,, 8⅓ ,,
45	30.33	2	3⅓d. ,, 6⅔ ,,
46	16.55	3	5 d. ,, 10 ,,
47	23.0	3	5 d. ,, 10 ,,
48	43.3	2½	4⅙d. ,, 8⅓ ,,
49	50.66	2	3⅓d. ,, 6⅔ ,,
50	13.0	3	5 d. ,, 10 ,,
51	26.66	2¾	4⅕d. ,, 9⅙ ,,
52	21.1	2½	4⅙d. ,, 8⅓ ,,
53	55.22	3	5 d. ,, 10 ,,
54	15.5	3	5 d. ,, 10 ,,
55	10.11	3	5 d. ,, 10 ,,

TABLE K.

Adulteration of Bombay Milk. (According to different Wards.)

Ward.	No. Examined.	No. of Genuine Samples.	No. of Samples not Genuine.	Percentage of samples which showed Adulteration with Water.
A	27	9	18	66.6
B	28	9	19	67.8
C	29	19	10	34.4
D	50	16	34	68.0
E	33	14	19	57.5
F	22	4	18	81.8
G	23	17	6	26.08

TABLE L.

To show that adulteration of milk varies according to the price charged.

	Price—Annas per seer.*			
	2	$2\frac{1}{2}$	3	4
Total number of samples examined ..	7	19	48	15
Number of adulterated samples ..	7	15	26	2
Percentage of adulterated samples...	100·	78·9	54·1	13·3
Average of water added to 100 parts of pure milk	40·2	33·1	23·3	21·7

Largest amount of "added" water known so far was 81.1 per cent. in a sample, the price of which was not known.

Genuine milk may be bought in Bombay for 4 annas a seer or $6\frac{2}{3}$*d.* (or 13 cents) per quart. Even at this rate one cannot

The Bombay Seer is equal to 24 ozs, while a seer in Calcutta and Poona is equal to 32 ozs.

* 2 Annas per seer=$3\frac{1}{3}$d. or $6\frac{2}{3}$ cents per quart.
$2\frac{1}{2}$ „ „ „ =$4\frac{1}{6}$d. „ $8\frac{1}{3}$ „ „ „
3 „ „ „ =5d. „ 10 „ „ „
4 „ „ „ =$6\frac{2}{3}$d. „ $13\frac{1}{3}$ „ „ „

be always sure of getting genuine milk, for out of 15 samples bought at this rate, two were found to be adulterated with water. At three annas a seer (=5*d.* or 10 cents per quart) more than half the number of samples were found to be adulterated. At 2½ annas per seer (=about 4*d.* or 8 cents per quart) nearly four-fifths of the samples were found to be watered, so that at this rate there is very little likelihood of getting genuine milk. At 2 annas per seer (=3⅓*d.* or 6⅔ cents per quart) it is impossible to get genuine milk in Bombay. The ordinary middle class in Indian cities can hardly afford to pay more than 2 to 2½ annas per seer for milk, which means that under the present conditions there is hardly any chance of their ever getting genuine milk. The richer and some of the middle classes in Bombay and Poona can perhaps afford to pay from 3½ to 4 annas per seer, but even then there is no guarantee of their getting absolutely genuine milk. It may be mentioned here that even at 4 annas per seer (=24 ozs.) *pure* and *clean* milk from a bacterial standpoint, it is almost impossible to obtain in Bombay. Even in some of the best samples, including those from European dairies, contamination with objectionable microbes is common as will be shown in Chapter IV.

In Calcutta also the price of milk is high—namely 4 annas per seer (=32 ozs.) or 2 annas per pound which is about the same as in Poona.

In Delhi and Allahabad milk is sold at 2 annas a seer (=32 ozs.) or one anna per pound. It is doubtful, however, as to whether genuine milk can be always had at this low price. No statistics regarding adulteration are available from these or other Indian cities.

In Ahmedabad and Surat, the price of genuine milk varies from 13 to 16 pounds per rupee.

CHAPTER IV.

BACTERIOLOGICAL EXAMINATION OF THE BOMBAY MILK SUPPLY AND THE QUESTION OF BACTERIAL STANDARDS FOR INDIA.

Chemical analysis of milk enables us to find out whether the milk is genuine, that is, whether there is any adulteration with water or any abstraction of fat, etc., but does not reveal anything as regards the contamination of milk with dirt, microbes of disease, etc. A sample of milk may be quite genuine chemically, but may be grossly contaminated with filth and even with dangerous bacteria. The public milk supply must be both genuine from a chemical point and *clean* from a bacterial point of view. It should be entirely free from contamination with the specific bacilli of the acute infectious diseases, *e.g.*, Tuberculosis, Typhoid, Cholera, etc. It should be also reasonably free from cow-dung, stable refuse and other objectionable sources of pollution. *Bacteriological examination of milk is, therefore, very important from a sanitary point of view.*

Sources of Bacteria in Milk.—Most observers assume that milk as secreted in the healthy udder is entirely free from bacteria. This has been disputed by others. Under suitable conditions, and with strict surgical precautions, it is quite possible to obtain bacteria-free milk at least in small quantities. The author has been able to get perfectly sterile samples on several occasions in Bombay. Mr. S. L. Stewart of Brookside Farms, Newburgh, New York, has been able to produce milk in large quantities almost free of bacteria. If milk in the udder is sterile, where do the bacteria come from ? Bacteria may squirm up the milk ducts and work their way into the milk cistern. Once there, they find ideal conditions for rapid growth : 'a warm, cozy dark home with an abundance of food.' This may account for the initial contamination of milk. It must be also remembered that the virus of Foot-and-Mouth-Disease, which is ultramicroscopic, the virus of " Milk Sickness " and the micrococcus causing Malta Fever, are found in the milk of affected animals, even though the udder may not be diseased. Bacteria may have their origin

in Mastitis and other diseases of the udder. Ordinarily the real contamination occurs *after* the milk has left the udder. From the act of milking to the final distribution and consumption of milk, numerous and varied are the possibilities of contamination. Eighteen possible sources are mentioned below. *During the process of milking* (Plate XXI) the possible sources are (1) the calf, which, in India, is usually allowed to have the first start in getting milk from its mother; (2) the dirty udders and flanks of the unwashed animal; (3) the unwashed hands of the milker; (4) the filthy clothing which the average milkman wears in India; (5) the insanitary habits of the milkman, *e.g.*, coughing, sneezing, nose-blowing with the fingers, etc.; (6) any communicable disease, *e.g.*, Tuberculosis, of the milkman; (7) the filth from the walls, ceiling, and the dust-and-dirt-laden air of the cattle stables (Plate XXX); (8) the dirty milk vessels; and (9) *the faulty water supply*. The water supply of the farm or cattle stable may become polluted by cases of cholera or typhoid on the premises. The writer isolated cholera vibrio from several wells in Bombay in June, 1912, and again in August, 1914. It is quite common to have wells near cattle stables, the water being used for drinking and washing purposes. *During transit and distribution* the possible sources of bacteria are :—(1) the dust and dirt from the vitiated air of a crowded city street getting into the open or partially covered milk-vessels; (2) the peculiar concentric ring of hay picked up from the filthy stables, or a piece of dirty rag which serves as a "cover" for the milk-vessels in most cases; (3) the filthy condition of third class cars on the suburban railways and the manner of conveying milk in the same; (4) the possibility of adulteration with filthy water during transit; (5) the insanitary condition of the milk-shops where milk is exposed for sale in open vessels; (6) the frequent handling of the milk while measuring it out to the consumer; (7) the filthy customs and habits of the retailer or hawker of milk in Indian cities; (8) the careless handling of the milk by the consumer; and (9) *the house-fly*. The house-flies are very common carriers of disease in India and it is not uncommon to find them indulging in a bath in the open milk-vessels. The contamination from each individual source may be small, but taken together from all the sources it would assume serious proportions.

It may be pointed out that a systematic and complete bacteriological examination of milk has never been attempted

before by anyone in India and consequently there are absolutely no data to start with. Considerable difficulty was experienced in the beginning to work out practical methods best suited for local conditions. The samples of milk were collected in special bottles provided for the purpose and were stoppered and sealed in the usual way. They were examined as soon as possible after collection. The following routine was followed in the examination of the samples :—

(1) *Preliminary dilution of the samples* with sterile water. These were made in a series of test-tubes as follows :—1:10, 1:100, 1:1000, 1:10,000 1:100,000 and 1:1,000,000. These dilutions were used for (2) and (3).

(2) *Microbes per c.c.*—Agar plates were used for this purpose and a count was made after incubating for 48 hours at 37° C.

(3) *Lactose Fermenters.*—MacConkey's Bile Salt medium (with lactose) was used in Durham's fermenation tubes and the results noted with regard to acid and gas formation. The dilutions used were from 1:10 to 1:1,000,000.

(4) *B. Enteritides Sporogenes.*—(Milk test only).—15 c.c. of the sample were used. The milk was heated for 15 minutes at 80° C, rapidly cooled, incubated anærobically, and was examined for the characteristic changes from four to five days.

(5) *B. Coli Communis.*—This was isolated on Neutral Red Agar and examined for acid and gas formation (MacConkey's Bile Salt media) and for Indol reaction, etc. (By *B. Coli* is understood the organism of type A as mentioned by Houston on page 172 of his " Studies in Water Supply, " 1913.)

(6) *Cholera.*—Cultures were made on Peptone water and examined for Cholera by cultural and biological tests in the usual way.

(7) *Typhoid.*—Drigalski-Conradi's medium and Neutral Red Agar were used.

(8) *Microscopic Examination of the Centrifugalised Sediment.*—50 c.c. of the milk were centrifugalised in the electric centrifuge for about ten minutes. Smears were made from the deposit, stained with carbol-fuchsin (1:10) and examined microscopically for Leucocytes, Streptococci, Staphylococci, and other micro-organisms that may be present.

(9) *Tuberculosis.*—The results of examination for Tubercle bacilli are described separately on page 69.

The samples of milk examined bacteriologically may be divided into four classes:—*Class I.*—Those collected from healthy animals under personal supervision and with the strictest precautions, and which were examined *immediately* after collection. *Class II.*—Those collected by the Chief Veterinary Inspector and his staff with ordinary precautions and sent to the Laboratory, the time elapsing between the collection and the examination varying from *three to four hours*. *Class III.*—Those bought at random in the different wards of the City from dairies, milk-shops, cattle-stables, railway stations, *Gowlees* and other milk vendors, by the staff of the Public Health Department. These samples fairly represent the quality of milk that is usually sold to the public in Bombay. As the "morning" milk is taken between 2 and 4 a.m. and sold a few hours later in the bazaar, *six to nine hours* pass before it arrives for examination at the Municipal Laboratory. *Class IV.*—Samples obtained from the Government Military Dairy in Bombay, the sources of the supply being Poona (Kirkee) and Ahmedabad. The milk is *pasteurised* and cooled, and kept at a temperature between 40° F and 50° F.

Class I.—Samples collected from healthy animals under personal supervision and with the strictest precautions.—Several cows and buffaloes belonging to a dairy were brought over to the Municipal Laboratory after being examined by a Veterinary Surgeon and certified to be entirely free from disease. The animals were thoroughly scrubbed and washed. Just before milking, the udders and neighbouring parts were washed, first with an antiseptic solution and finally with sterile water. The milking was done by the manager of the dairy himself, his hands being rendered surgically clean in the usual way. Most of the milk was drawn in sterile glass beakers while a few drops were drawn directly into slant Agar tubes. After making the necessary dilutions, the samples were immediately subjected to the routine examination for microbes per c.c., Lactose Fermenters, etc., with the following results:—

1. *Microbes per c.c.*—The average of several samples collected on two different occasions was found to be 292 *microbes per c.c.* This was probably due to the too frequent manipulations involved in diluting the milk and preparing the plates, etc. The slant Agar tubes in which milk was directly drawn were found to be sterile. This would indicate that milk drawn in small

amounts with strictest precautions from healthy and clean animals is practically sterile.

2. *Lactose Fermenters* were *absent* in 1 c.c. and less of milk, in all the samples examined.

3. *Examination for B. Coli communis, B. Enteritides Sporogenes, Streptococci, Cholera Vibrio, B. Tuberculosis and B. Typhosus* was negative in every case. These results compare favourably with those obtained by several observers in Europe and in America.

Park[1] in 1901 found the average bacterial count per cubic centimeter in samples of milk from six separate cows examined five hours after collection to be 6,000, the lowest count being 400.

Von Freudenreich[2] (1902) obtained milk under the strictest aseptic precautions from 28 cows. The bacterial count of the mixed milk varied from 65 to 680 microbes per c.c. Continuing his experiments, Freudenreich in 1903[3] examined the udders and the milk in the udders of 15 cows, in 13 cases immediately after slaughtering. The organisms found were mostly cocci. B. Coli was never found.

Willem and Miele[4] in 1905 examined a sample of milk containing 25 bacteria per c.c. The milking was done in a special place. The udders and teats were washed with an antiseptic solution and all possible precautions were taken during milking.

MacConkey in 1906[5] found that with ordinary care and cleanliness it is possible to obtain milk which contains less than 1,500 microbes per c.c., and in which gas-forming organisms are absent in less than 50 c.c.

Class II.—Samples collected by the Chief Veterinary Inspector and his staff with ordinary precautions.—68 samples were examined in all, and it was found that B. Enteritides Sporogenes, Cholera Vibrio and B. Typhosus were not detected in any of the samples. B. Coli was detected in 24 samples or in 35.29 per cent., and Streptococci in two samples

[1] Park, W. H. "The great bacterial contamination of the milk of cities," etc. *Journal Hyg., Vol. I,* 1901, page 391.

[2] Von Freudenreich; "Milchsäurefermente und Kasereifung" *Cent. f. Bakt*; 2 *Abt.*, Vol. VIII, 1902, page 674.

[3] Von Freudenreich. "Ueber das Vorkommen von Hakterien im Kuhenter." *Cent. f. Bakt*; 2 *Abt.* Vol. X, 1903, page 1901.

[4] Willem and Miele; "Procedé poue l'obtention dulait au aseptique Compte Rend. du 13 Cong. internat. d'Hyg. Brux, 1903." Vol. III, page 67.

[5] MacConkey, "A contribution to the Bacteriology of Milk." *Journal of Hyg., Vol.* VI, 1906, page 385.

only. This leaves for consideration only microbes per c.c. and lactose fermenting organisms. Taking first the microbes per c.c., it will be seen that the highest count was found to be 46,150,000, while the lowest count was 450,000. The average number expressed in millions was as follows :—

TABLE I.

*Microbes per c.c. in 68 samples—(Class II.)

Date.	No. of samples.	Average No. of microbes per c.c.	Average of 68 samples.
June 1913 ..	8	8,981,000	17,103,000
September ,, ..	12	16,195,000	
December ,, ..	12	18,833,000	
January 1914 ..	6	10,416,000	
April ,, ..	9	19,000,000	
May ,, ..	21	19,767,000	

TABLE II.

Microbes per c.c. in 68 samples expressed in millions—(Class II.)

Less than 1 Million.	Above 1 but less than 3	Above 3 but less than 5	Above 5 but less than 10	Above 10 but less than 20	Above 20 but under 50
1	1	4	14	30	18

Most of the samples showed a count of more than five millions of microbes per c.c.

The above figures are only approximate, for as Savage says, " There are no nutrient media and no known conditions of growth which will allow all the bacteria in milk to develop."

Lactose Fermenters.—Out of the 68 samples examined, only four, or 5.9 per cent., did not show any lactose fermenters in 1 c.c. and less of milk. The following results were obtained :—

TABLE III.

No. of samples.	1·0 c.c.	0·1 c.c.	0·01 c.c.	0·001 c.c.	0·0001 c.c.	0·00001 c.c.	0·000001 c.c.	Remarks.
4 ..	—	—	—	—	—	—	—	About 6% did not show lactose fermenters in 1 c.c and less of milk. The same percentage of samples showed L. F. in the dilution of—— 1:1,000,000.
1 ..	+	—	—	—	—	—	—	
5 ..	+	+	+	—	—	—	—	
16 ..	+	+	+	+	—	—	—	
21 ..	+	+	+	+	+	—	—	
17 ..	+	+	+	+	+	+	—	
4 ..	+	+	+	+	+	+	+	

Total — 68 samples. + = Present. — = Absent.

B. Coli Communis was detected in 24 samples out of 68, or in about 35 per cent. These results compare favourably with those obtained in the third series of samples. (*Vide* Tables VI and VII.)

Class III.—Samples bought at random from a variety of sources *e.g.*, dairies, milk-shops, cattle-stables, railway stations, individual milk-vendors or Gowlees, etc.—Two hundred and forty such samples were examined in the same manner as Series I and II. Only a brief summary of the results is given below :—

1. *Microbes per c.c.*—The highest count was 118,400,000 and the lowest was 250,000 during a period of about 12 months. The highest average figures were reached during May as will be seen from *Table IV.*

TABLE IV.

Microbes per c.c.—Average of 240 Milk samples.—(Class III).

Date.	No. of samples.	Average of total count of microbes per c.c. on Agar at 37° C for 48 hours.	Average mean-temperature. Fahr°.	Average humidity.	Remarks.
1913.			°F.		
April ..	12	46,363,000	82·	·761	
May.. ..	30	63,481,000	86·5	·723	
June ..	2	34,125,000	83·7	·822	
July.. ..	31	35,801,000	81·5	·864	
August ..	10	29,750,000	81·4	·815	Average num-
October ..	18	38,027,000	82·7	·785	ber of micro-
November ..	24	30,297,000	79·8	·697	bes per c.c.
1914.					from April
January ..	18	30,905,000	79·8	·699	1913 to July
February ..	24	26,366,000	76·0	·684	1914
March ..	21	26,131,000	78·0	·784	=36,385,000.
April ..	18	22,105,000	82·0	·747	
June ..	16	35,462,000	85·0	·802	
July.. ..	16	39,025,000	82·0	·866	
Total ..	240	....	....	....	

TABLE V.

Microbes per c. c. in 240 samples of milk expressed in millions—(Class III.)

More than 1 but less than 5 millions.	More than 5 but less than 10	More than 10 but less than 20	More than 20 but less than 30	More than 30 but less than 50	More than 50 millions.
3	9	32	82	68	46

The majority of samples (nearly 82%) showed a count of more than 20 millions; while about 19% showed more than 50 millions of microbes per c.c.

2. *Lactose fermenters.*—The results are tabulated below:—

TABLE VI.

Lactose fermenters in 240 samples of milk—(Class III.)

No. of Samples.	1 c.c.	0.1 c.c.	0.01 c.c.	0.001 c.c.	0.0001 c.c.	0.00001 c.c.	0.000001 c.c.
2 ..	+	+	+	+	—	—	—
17 ..	+	+	+	+	+	—	—
40 ..	+	+	+	+	+	+	—
181 ..	+	+	—	+	+	+	+
Total..240 ..	..	..	..	..	..	..	..

+ = Present; — = Absent.

All the samples showed the presence of lactose fermenting organisms in 1 c.c. and less of milk. Out of the 240 samples 182 or 75.8% showed lactose fermenters in the weakest dilution used, *viz.*, in 0·000001 c.c. of milk. Lactose fermenters were found to be absent in 0·0001 c.c. and less of milk in two samples only. These results are extremely bad as compared to those in *Table III.* (q.v.)

TABLE VII.

Microbes per c.c. in Bombay milk—(Class III.)

(Distributed according to Wards.)

Ward.	No. of Samples.	Average No. of microbes per c.c. from April 1913 to July 1914.	Remarks.
A ..	37	34,331,000	Average 38,162,000
B ..	38	40,081,000	
C ..	35	37,744,000	
D ..	33	39,963,000	
E ..	39	37,786,000	
F ..	28	49,218,000	
G ..	30	28,013,000	
Total ..	240	......	....

TABLE VIII.

Lactose fermenters in Bombay milk—(Class III.)

(Distributed according to Wards,)

Ward.	No. of samples.	1. c.c.	0.1 c.c.	0.01 c.c	0.001 c.c.	0.0001 c.c.	0.00001 c c.	0.000001 c.c
A ..	3	+	+	+	+	+	—	—
	8	+	+	+	+	+	+	—
	26	+	+	+	+	+	+	+
Total ..	37							
B ..	1	+	+	+	+	+	—	—
	2	+	+	+	+	+	+	—
	35	+	+	+	+	+	+	+
Total ..	38							
C ..	2	+	+	+	+	+	+	—
	33	+	+	+	+	+	+	+
Total ..	35							
D ..	1	+	+	+	+	—	—	—
	3	+	+	+	+	+	+	—
	29	+	+	+	+	+	+	+
Total ..	33							
E ..	2	+	+	+	+	+	—	—
	12	+	+	+	+	+	+	—
	25	+	+	+	+	+	+	+
Total ..	39							
F ..	3	+	+	+	+	+	—	—
	7	+	+	+	+	+	+	—
	18	+	+	+	+	+	+	+
Total ..	28							
G ..	1	+	+	+	+	—	+	—
	8	+	+	+	+	+	—	—
	5	+	+	+	+	+	+	—
	16	+	+	+	+	+	+	+
Total..	30							
Grand Total	240.							

+ = Present. — = Absent.

3. *B. Enteritides Sporogenes,* (Milk test only).—Twenty-nine samples out of 240, or 12 %, gave positive tests with the production of the characteristic changes in the milk. Animal experiments were tried in a few cases but with negative results.

4. *B. Coli* was detected in 225 samples out of 240, giving 93.7 per cent., as compared with 35.3 per cent. in Series II.

5. *Streptococci.*—The centrifugalised stained deposit examined microscopically showed the presence of streptococci in 28 samples out of 240, or in 11.7 %, as against 2.9 % in Series. II.

6. *Examination for B. Typhosus, B. Tuberculosis and Cholera Vibrio was negative in all cases.*

Class IV.—118 Special Samples collected from the Government Military Dairy, Bombay.—The milk is supplied daily from Poona (Kirkee) and Ahmedabad. It is first pasteurised at 170° F. for two minutes, rapidly cooled down to nearly freezing point and then brought to Bombay in special cans with cold packing outside. After arrival in Bombay the milk is again pasteurised, cooled and held at a temperature between 40° and 50° F. The samples were collected in special bottles, packed in a case containing ice, and were examined immediately after arrival at the Municipal Laboratory. The results are tabulated below :—

TABLE IX.

Microbes per c.c. in 118 samples of milk—(Class IV.)

Source of supply.	Months.	No. of samples examined.	Average number of microbes per c.c.
	1914.		
Poona	August	11	9,407,000
,, ...	September	20	12,845,000
,, ...	October	19	16,650,000
,, ...	November	21	14,390,000
,, ...	December	5	11,618,000
Poona Total.. ..	....	76	13,644,000
Ahmedabad	August	12	9,462,000
,, ...	September	20	12,528,000
,, ...	October	10	18,107,000
Ahmedabad Total ..	....	42	12,980,000
Grand Total Average.	....	118	13,408,000

The average number of microbes per c.c. in 118 samples examined was about 13 millions ; these figures compare favourably with those found in Bombay milk (Class III. See Table IV). In another series of 50 samples of pasteurised milk from the same source examined recently, the average bacterial count was found to be 7 millions only.

All the above samples showed Lactose Fermenters in 1 c.c., 0.1 c.c. and 0.01 c. c. ; only two from Ahmedabad and three from Poona showed their presence in a dilution of one in a million as detailed in the following statement :—

TABLE X.

Lactose Fermenters in 118 samples of milk—(Class IV.)

Source of supply.	No. of Samples.	Dilution of Milk used.						
		1 c.c.	.1 c.c.	.01 c.c.	.001 c.c.	.0001 c c.	.00001 c.c.	000001 c.c.
Ahmedabad.	2	+	+	+	+	—	—	—
,, ..	8	+	+	+	+	+	—	—
,, ..	30	+	+	+	+	+	+	—
,, ..	2	+	+	+	+	+	+	+
Poona ..	2	+	+	+	+	—	—	—
,, ..	31	+	+	+	+	+	—	—
,, ..	40	+	+	+	+	+	+	—
,, ..	3	+	+	+	+	+	+	+

+ = Present ; — = Absent.

Neither B. Coli nor B. E. Sporogenes were detected in any of the 118 samples. The centrifugalised stained deposit examined microscopically *did not show any Streptococci.* These favourable results are to be ascribed to the fact that all the above samples were pasteurised before collection.

Some remarks may be now made regarding the *significance* of some of the foregoing results. *Microbes per c.c.*—As has been already said, all the colonies counted at any one time do not by any means give a *true* count of all the bacteria present in milk, for there are so many varieties of microbes found in milk that it is impossible for them *all* to grow on the same medium. It cannot be denied, however, that the count has a *relative* value when made under precisely identical conditions. It may be argued that all the bacteria found in milk are not harmful. It must be remembered, however, that milk containing an excessive number

of microbes cannot be said to be a suitable food, particularly for infants. Besides, 93.7% of the samples (Class III) examined, showed the presence of B. Coli communis. Unfortunately, milk is not a transparent liquid or else the growth of microbes would have been visible to the naked eye. To get some idea of the bacterial counts found in Bombay, the figures may be compared to those of sewage in London and Boston, and milk in London, New York, Boston and Bombay.

		Average for	Microbes per c.c.	Name of the investigator or authority.
Sewage	1. London ..	1894 to 1901	2,000,000 to 11,000,000	Rosenau.
	2. Boston ..	1894 to 1901	2,800,000	Rosenau.
Milk.	1. London ..	Dec. to Feb...	3,000,000 to 5,000,000	Eyre.
	,,	June to Sept..	20,000,000 to 30,000,000	Eyre.
	2. New York.	In Winter ..	1,000,000	Park.
	,,	In Summer ..	5,000,000	Park.
	3. Boston ..	1904	2,300,000	Bergey.
	4. Bombay..	April 1913 to July 1914. (240 samples.)	36,385,000	Joshi.

It must be borne in mind that too much stress should not be laid on these statistics, as different investigators may have employed different methods and the results may not be strictly comparable. At any rate, it is quite evident that Bombay enjoys the dubious honour of standing *first* in the above list.

There are at least *three main factors which influence the multiplication of bacteria in milk:* (1) *Time*, (2) *Temperature*, and (3) *Conditions of collection, storage and distribution of milk.*

(1) **Time.**—By "time" is meant the interval between the withdrawal of milk from the cow or buffalo and its examination at the Laboratory. A glance at the figures given above will show the following :—

Number of samples.	Class.	Average "Time."	Average number of microbes per c.c.
.... ..	I	Immediately examined.	292
68 ..	II	3 to 4 hours	17,103,000
240 ..	III	6 to 9 hours	36,385,000

In these experiments, the temperature was practically constant, but the conditions of collection, etc., were different, and this must be borne in mind when comparing the results. The influence of *time* on the growth of bacteria in milk obtained under aseptic conditions has been observed in several samples examined in Bombay by the author. The following figures are typical of many others. The sample was collected with strict precautions. Just before milking, the udders and neighbouring parts were washed, first with an antiseptic solution, and finally with sterile water. The hands of the milker were rendered surgically clean in the usual way and the milk was drawn in sterile glass flasks.

	Microbes per c.c.	Lactose Fermenters.
Shortly after milking, the sample contained ..	198	— in 1 c.c. and less.
One hour „ „ „ „ „ ..	304	— in 1 c.c.
Two hours „ „ „ „ „ ..	624	— in 1 c.c.
Three „ „ „ „ „ „ ..	1,035	— in 1 c.c.
Four „ „ „ „ „ „ ..	7,200	+ in .1 c.c. and more.
Five „ „ „ „ „ „ ..	19,400	+ in .1 c.c. and more.

+ = Present; — = Absent.

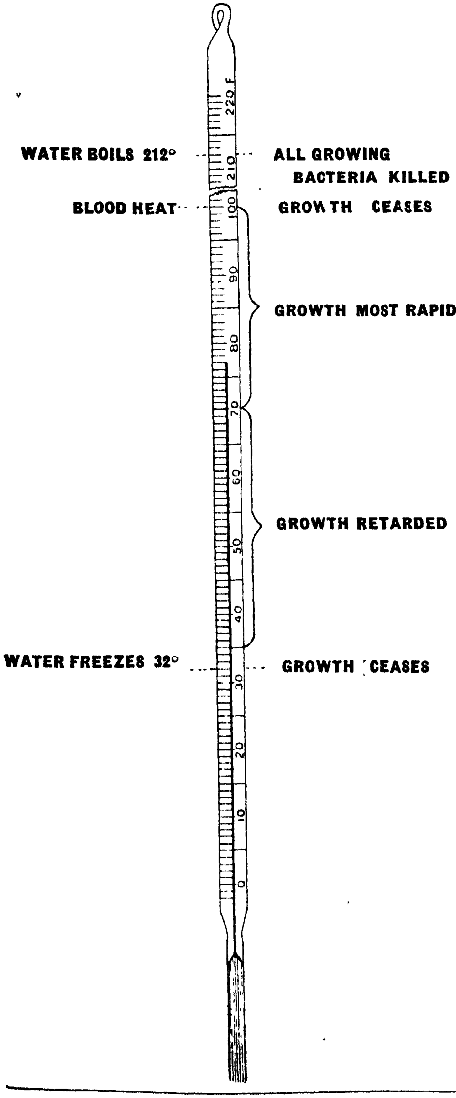
The following figures from Freudenreich are also very instructive :—

Shortly after milking, the sample contained	9,000	microbes per c.c.
1 hour „ „ „ „ „	31,750	„ „ „
2 hours „ „ „ „ „	36,250	„ „ „
4 „ „ „ „ „ „	40,000	„ „ „
7 „ „ „ „ „ „	60,000	„ „ „
9 „ „ „ „ „ „	120,000	„ „ „
25 „ „ „ „ „ „	5,000,000	„ „ „

It may be concluded that under identical conditions of collection, transportation, etc., and with a constant optimum temperature, the longer a milk sample is kept the greater the number of bacteria in it, up to a certain limit.

II. Temperature.—This is a very important factor here in India. It has been found that the majority of bacteria met with in milk grow best at about 25°C to 35°C (or 77°F to 95°F). At a lower temperature, (15°C and below) they multiply very

Influence of Temperature on the growth of Bacteria ordinarily found in Milk.



little. At a higher temperature, the different bacteria have their different *thermal death points*. In other words, a certain amount of heat is essential and a certain amount is fatal to the growth of bacteria. Each particular variety of bacteria grows best at a certain temperature called the *optimum ;* each also has an upper and a lower temperature limit beyond which its growth is arrested. The accompanying diagram illustrates these points.[1] The atmospheric temperature in Bombay corresponds very closely to the most favourable temperature for bacterial growth in milk, namely, 25°C to 35°C or 77°F to 95°F, and accounts partially for the high counts obtained. It will be seen from Table IV that the highest number of microbes per c.c. (63 millions) was found during May, which is the hottest month in Bombay and Western India, the average mean temperature during May 1913 being 86.5. In July and August, on account

[1] U.S. Department of Agriculture, Bulletin 348, p. 10.

of the monsoon, it is comparatively cooler, and correspondingly the figures show a lower count (29 to 35 millions) than in May. In October the temperature again rises (82.7) and with it the number of microbes. From November to February there is a gradual decline both in temperature and in the number of bacteria.

The relative increase of bacteria in milk held at different temperatures is given as follows[1] :—

Milk held at	Relative number of bacteria at the end of				
	0 hour.	6 hours.	12 hours.	24 hours.	48 hours.
68° Fahr ..	1	1.7	24.2	6,128.0	357,499.0
50° Fahr ..	1	1.2	1.5	4.1	6.2

In the foregoing table, 1 is assumed to represent the numbers of bacteria in the fresh milk, and the relative numbers which will be found at the end of six, twelve, twenty-four and forty-eight hours, at the two temperatures, are shown in the succeeding columns. These figures are based on a number of actual counts and illustrate the effect of a difference of 18° on the multiplication of bacteria. If the milk had contained at the beginning 1,000 bacteria, the part held at the lower temperature would have contained at the end of twenty-four hours 4,100 bacteria, while the other would have contained at the same stage, 6,128,000."

III. Conditions of collection, distribution, etc.—The cleanliness of the methods employed in milking, etc., has a direct bearing on the bacterial content of milk. It affects not only the total *number* of bacteria but also the *kind* of bacteria in milk. As a rule, the dirtier the milk the greater is the number of microbes in it. This has been clearly proven by the results already tabulated in the case of all the four different classes of samples collected under widely different conditions.

To sum up, *the enumeration of microbes per c.c. in milk serves as an index to its* (1) *age,* (2) *temperature at which it was held, and* (3) *the cleanliness of the methods employed in its collection, etc.* A favourable combination of all these three factors will result in an excessive multiplication of the bacteria present.

[1] U.S. Department of Agriculture, Bulletin 348, p. 11.

As regards the presence of *lactose fermenting organisms and B. Coli* in Bombay milk, a comparison may be made between the figures in Table III and those in Table VI. In the former case only 5.9 per cent. of samples showed lactose fermenters in 0·000001 c.c. and more of milk, while in the latter case the percentage of samples showing lactose fermenters in the same dilution was 75.8, or nearly twelve and a half times as much. In Class II, B. Coli was found in 35.3 per cent. of the samples, while in Class III in 93.7 per cent. The presence of organisms of the B. Coli group in such large numbers indicates pollution with cow-dung, etc. This is not at all astonishing, when one remembers the filthy condition of the stables, etc., where milking is usually carried on. Out of the samples of milk collected with the strictest sanitary precautions, not one showed any " fæcal bacilli." This taken together with the results tabulated in Tables III and VI would indicate that *the presence and the number of lactose fermenting organisms and the presence of B. Coli in milk depend mostly on the amount of cleanliness observed in the collection, storage and distribution of milk*. The figures for milk of Class III (Table VI) show an appalling amount of manurial and other undesirable pollution of Bombay milk as is ordinarily found in the local market. The figures obtained in samples of Class II and Class IV demonstrate the advantages of cleanly methods in handling milk.

The *kind* of bacteria found in milk are even more important than the mere enumeration of the total *number* of bacteria. The presence of B. Coli in about 94 per cent. of Bombay milk and the detection of lactose fermenters in a dilution of one in a million of milk, clearly show that the Bombay milk supply is grossly contaminated with manure and other dirt. The conditions of a perfect bacterial indicator are defined as follows by William G. Savage :—1. It should be abundant in the substances for which its presence serves as an indicator. 2. It should be absent, or at least relatively absent, from all other sources. 3. It should be easily isolated and numerically estimated. 4. Its characteristics should be definite and not liable to variation, whereby its distinctive characters might be impaired.

B. Coli, as an indicator of the manurial contamination of milk, fulfils all these conditions very adequately. The same may be said regarding the organisms which are closely allied to B. Coli. The enumeration of B. Coli and allied organisms in a sample of milk may be taken generally as a fairly reliable measure of the

degree of pollution of that sample. It is, however, by no means quite so simple to interpret correctly the significance of the presence and number of B. Coli and allied organisms in milk. A great deal would depend upon *time* and *temperature* as discussed already. If it were an universal custom to thoroughly cool milk and maintain it at a temperature so low that B. Coli could not multiply in it, then one could lay down definite standards for B. Coli by which the amount of pollution could be measured. Bearing in mind the various insanitary conditions under which milk is collected and distributed in India, and the various local factors, *e.g.*, favourable temperature for bacterial growth, etc., it may be assumed that *the presence of B. Coli and allied organisms in large numbers indicate manurial and other undesirable pollution of milk.*

B. Enteritides Sporogenes in milk.—It has been shown that the spores of this organism are present in considerable numbers in cow-dung. According to Savage, the estimation of the number of spores in milk is valuable, as B. Enteritides sporogenes is an organism which does not multiply in milk. The ordinary test for the detection of this bacillus cannot be considered as conclusive. In 29 out of 240 samples (12%) B. Enteritides sporogenes was found in Bombay. Whatever may be the significance of its presence, it does not seem to be very common in Bombay milk.

Microscopic examination of the Centrifugalised and Stained Sediment.—A microscopic study of the milk sediment gives one a general idea of the number and kind of bacteria and of the cellular element present. The presence of streptococci, pus cells, leucocytes, etc., can be also detected by microscopic examination. Besides, one can obtain general information concerning the nature of the dirt in the milk sample. The centrifugalised sediment is composed partly of cellular elements, *e.g.*, leucocytes, etc., and partly of bacteria, sand and dust particles, cotton fibres, hairs, manurial matters, and particles of straw, 'kadbi' and other feed. After a little practice one can fairly distinguish certain types of bacteria which are characteristic of stable-refuse, cow-dung, etc. A high leucocyte count accompanied by streptococci usually indicates diseased udders. The presence of pus cells may indicate purulent inflammation of the udders. Microscopic examination would be also of great value when the source of the sample is known, for then the diseased animal could be traced.

The Significance of Streptococci in Milk.—The streptococcus which is usually associated with Mastitis is called *streptococcus mastitides* by Savage. Out of 36 cases of mastitis in cows investigated by Savage, nearly 75 per cent. were due to streptococci.[1] Further investigations were made by Savage to determine whether these streptococci were pathogenic to man. He made a comparative study of the human and bovine groups of streptococci with regard to their virulence, etc. He found that although the two groups were morphologically and culturally indistinguishable, they showed a wide divergence when their action towards animals was considered. Savage concludes from his researches that "under ordinary conditions the *streptococcus mastitides* is not a cause of human disease."

Moore found[2] streptococci associated with many diseases of cattle, sheep and horses. Streptococcus has been also found in milk derived from healthy udders. Reed and Ward observed this in the case of a cow from 1897 to 1900.[3] A post-mortem examination of the glandular tissue of the udder was made and streptococci were isolated.

Pus Cells in Milk.—It is not easy to accurately distinguish between pus cells and leucocytes in milk. A leucocyte in fluids other than blood—milk for example—soon undergoes changes which render it almost indistinguishable from a pus cell. Some observers regard all noticeably clumped cells as pus cells. Others regard all polynuclear neutrophilic cells as pus cells. The writer distinguishes a normal healthy leucocyte from a pus cell in that the latter is regarded by him as a leucocyte in a state of degeneration, showing a swelling of the cell, which contains granular detritus.

Stokes and Wegefarth carried out a systematic examination of milk for pus cells. The samples were obtained from *three grades* of cows kept under different sanitary conditions. (1) *The first grade*—100 cows kept in the country in a modern, sanitary stable and milked in a cleanly manner. The average of ten microscopic fields showed 1.1 *pus cell* to a single microscopic field. (2) *The second grade* consisted of 50 cows kept in the country, but in a badly ventilated and dirty stable—no precautions were taken in collecting the milk. The samples were examined in the same way

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[1] Savage: "Milk and the Public Health."

[2] Moore; "Observations concerning the significance of Streptococci in comparative Pathology." *American Vet. Review*, 1900, Vol. XXIII.

[3] H. C. Reed and A. R. Ward, "Streptococci in Market Milk." *American Medicine*, February 14th, 1903, p 257.

as (1) and gave an average of 11.3 pus cells to a single field. (3) *The third grade* consisted of 100 cows kept in the city, always confined in a filthy stable. The milk was collected under veterinary supervision and on being examined in the same manner gave an average of 19.2 pus cells to a single microscopic field.

From these results the obvious conclusion is that cows kept in the country under sanitary and hygienic conditions are less capable of causing disease through their milk than those kept in the city under the conditions of grade 3. In Bombay and other large Indian cities, most of the milk is obtained from cattle kept under the conditions of grade 3. 308 samples of mixed market milk were examined microscopically by the author. All contained leucocytes in varying numbers—the polymorphonuclear variety being predominant. True pus cells were very rarely found. Streptococci were found only in 2.9 *per cent.* of samples of class II, but in 11.7 *per cent.* of samples of class III.

Miller[1] draws the following conclusions with regard to leucocytes and streptococci in milk :—

1. Many leucocytes and streptococci are present in the normal milk of a healthy cow.

2. Leucocytes and streptococci are as a rule more numerous in the milk of diseased than in that of healthy cows.

3. No satisfactory method has been devised for distinguishing the pathogenic from the non-pathogenic streptococci in milk. Their significance is therefore a matter of further study.

Tubercle Bacilli in Milk.—The following figures will show the frequency with which Tubercle bacilli have been found in milk in English and American cities :—

Cities.	No. of Samples Examined.	Percentage containing Tubercle Bacilli.	Investigator or Authority.
London (1908)	....	11.6	William G. Savage.
Manchester (1908) ..	....	8.28	William G. Savage.
New York (1910) ..	107	16.0	Hess.
Chicago (1910)	144	10.5	Tonney.
Washington (1906) ..	233	6.7	Anderson.

[1] Miller, Wm. W. : "The significance of Leucocytes and Streptococci in milk." *Hyg. Lab Bull,* No. 56. March 1909. Washington, U. S. A.

Are tubercle bacilli conveyed by milk in India? A systematic examination of Bombay milk for B. Tuberculosis was made by the author during four years (1910—1913 inclusive). The total number of the samples examined was 741. Forty-eight samples, or 6.47 per cent., showed the presence of *acid-fast bacilli,* but *in not a single sample tubercle bacilli could be demonstrated by animal experiments.* These results have been confirmed independently by those at the Bombay Bacteriological Laboratory, Parel, where 100 samples of cows' milk were recently examined for tubercle bacilli, but *in no instance did the guinea-pigs develop tuberculosis.* Further investigation in other cities of India is necessary before drawing final conclusions, but so far as our present knowledge goes, it may be concluded that *in India, tubercle bacilli are rarely, if at all, conveyed by milk.*

The value of bacteriological examination of milk in India cannot be denied in the light of the foregoing results. Chemical examination is no doubt important, as it gives us information as to whether a sample of milk is genuine or not, that is whether it is "watered" or deficient in fat, etc. If clean and pure water be added, it would not be directly injurious to health. If, however, a sample of milk shows a very high count of bacteria, most of which are of fæcal origin, or the presence of a pathogenic microbe, (like cholera or typhoid), then its bearing upon the public health is quite obvious. Again, a sample of milk may be quite genuine from a chemical point of view, but very objectionable from a bacteriological standpoint. The following two samples, (A and B), may be cited to illustrate this point:—

Samples.	*Chemical Examination.*				*Bacteriological Examination.*	
	Spec: Grav: at 60° F.	Total Solids %	Fat %	Non-fatty Solids %	Microbes per c.c.	Lactose fermenters present in
'A'..	1030	17·14	6·5	10·64	47,100,000	0·000001c.c. and more
'B'..	1026	15·44	6·4	9·04	52,850,000	0·000001c.c. and more.
					(B. coli present in both.)	

Both the samples are *genuine* from a chemical point of view. Bacteriological examination shows, however, a very high

count, the presence of lactose fermenters in 0.000001c.c. and more, and the presence of B. Coli communis. Surely such samples cannot be considered harmless specially for the tender gastro-intestinal mucous membrane of an infant.

In a routine bacteriological examination of milk in India it would be necessary to adopt only the following procedure :—

1. *Microscopic examination* of the centrifugalised sediment, especially for leucocytes, pus cells and streptococci.

2. Number of microbes per c.c. (count on Agar plates.)

3. Lactose fermenters in different dilutions, and

4. Examination for B. Coli communis and B. Enteritides sporogenes.

Dr. Eastwood in his Report to the Local Government Board (1909) on American Methods[1] emphasises the great importance of bacteriological examination of milk in the interests of public health. A knowledge of the bacterial content of milk is very useful in the control of the milk supply of a city. Dr. Eastwood says that " the results already obtained in America by the use of bacteriological methods are worthy of admiration." The following example from a Philadelphia report is quoted by him to illustrate the prompt efficacy of the microscopic examination of milk. " Recently a child was made sick by the use of milk ; the sample, which was sent to the Laboratory, was found to contain pus and streptococci in large numbers. The dairyman was notified, his herd inspected and the infected cows excluded within six hours." The results achieved by Dr. Goler, Health Officer of Rochester, N. Y., in the improvement of the milk supply of that city, are also worth mentioning. The City of Rochester, N.Y., has a population of 200,000 who use 70,000 quarts of milk daily. " Every year bacterial counts of 1,000 samples are made ; fifty per cent. of these now yield less than 100,000 bacteria per c.c. Dr. Goler is a strong believer in the value of the bacterial count, and considers that the reduction which he has effected in the bacterial content of Rochester milk is one of the causes which have brought about a diminution of infantile mortality." Dr. Eastwood concludes, "routine bacteriological examinations of samples for the guidance of the milk inspection service are valuable and should be adopted. They afford the most reliable, the cheapest, and often the quickest means of discovering when

[1] (New Series No. 1) Dr. Eastwood's *Report to the Local Government Board* on " American Methods for the Control and Improvement of the Milk Supply," 1909, page 60.

milk has been improperly handled. The practical importance of the work is well put by Rosenau: 'The activities of our health officer were at first directed almost exclusively to the prevention of sophistication of milk, detected by chemical methods, to the neglect of the valuable information obtained from bacterial examination. The addition of water to milk and the extraction of cream are fraudulent practices, but, as a rule, have only a secondary bearing upon the public health. The bacteriological examination of milk gives us a clue to the cleanliness of the methods employed, the temperature and the age of the milk. The health officer who has the advantage of bacteriological assistance knows that the milk of dairies containing excessive numbers of bacteria is dirty, old, or warm. With a bacteriological count as a guide it is comparatively easy to determine the cause of the trouble and to institute proper means to correct it. The enumeration of bacteria in milk is, therefore, one of the readiest and cheapest methods at the disposal of health officers to determine the general sanitary quality of the market milk supply. The Laboratory results serve not only as a guide to direct the efforts of the health officer, but confirm the conclusions arrived at from an inspection of the dairies and dairy farms.' I consider that Rosenau's statements are fully justified by what has already been accomplished in America."

BACTERIAL STANDARDS.

The first attempt to adopt a bacterial standard was made by the New York Board of Health in 1900. According to this, no milk was allowed to be sold in New York which contained over 1,000,000 bacteria per c.c. This standard was considerably modified later on. Boston has a *legal standard* of 500,000 microbes per c.c. According to Rosenau the number of bacteria per c.c. in clean milk should never exceed 100,000. It must be remembered that conditions in America are quite different from those obtained in India, and if a standard is to be adopted in India, it would have to be done with due regard to the various factors which affect the bacterial content of milk here. The most important of these are, (1) the local conditions of collection and distribution of milk, (2) the temperature at which the milk is held, and (3) the time elapsing between the collection of the milk and its consumption.

A bacterial standard should not consist merely of the minimum number of microbes per c.c. The *kind* of bacteria in milk are even more important than the *number*, and this must be taken into consideration in fixing the standards. There are many difficulties in the way of adopting numerical bacterial standards, and at the present stage of our knowledge it is questionable whether such a standard should be fixed for *legal* purposes. Bacterial standards for milk in India would be, however, very useful as guides for *administrative* purposes. Further research is necessary before fixing any such permanent standards. In the meantime, in the light of the results obtained in Bombay, the following standard for pure milk is suggested as a provisional measure for Bombay City.

1. *Microbes per c.c.*—The total number of microbes per c.c. should not exceed two millions during the cold weather (November to March) and five millions during the hot and rainy seasons (April to October).

2. *Lactose Fermenters.*—These should be absent in at least 1 c.c. of the sample, if it is taken with strict sanitary precautions.

(*a*) *During the cold season* (*November to March*) the sample is of—

Pure	milk, if lactose	fermenters	are	absent in	1	c.c.
Good	,,	,,	,,	,,	0.1	c.c.
Fair	,,	,,	,,	,,	0.01	c.c.
Unsatisfactory	,,	,,	,,	present	0.01	c.c.
Bad	,,	,,	,,	,,	0.001	c.c.
Contamnated	,,	,,	,,	,,	0.0001	c.c.
Highly-contaminated	,,	,,	,,	,,	0.00001	c.c. and less.

(*b*) *During the hot weather and Monsoon* (*April to October.*)—

Pure	milk, if lactose	fermenters	are	absent in	0.1	c.c.
Good	,,	,,	,,	,,	0.01	c.c.
Fair	,,	,,	,,	,,	0.001	c.c.
Unsatisfactory	,,	,,	,,	present	0.001	c.c.
Bad	,,	,,	,,	,,	0.0001	c.c.
Contamnated	,,	,,	,,	,,	0.00001	c.c.
Highly-contaminated	,,	,,	,,	,,	0.000001	c.c. and less.

3. *Microscopic examination of the centrifugalised sediment* should show only a few leucocytes and perhaps a few cocci and

bacilli, but pus cells and (pathogenic) streptococci should be absent. There should be no leucocytosis, especially of the polymorphonuclear variety.

4. *Pathogenic microbes, e.g.,* Tubercle bacilli, Cholera Vibrio, B. Typhosus, etc., must be *always absent.*

SUMMARY AND CONCLUSIONS.

1. *The principal factors affecting the bacterial content of milk are :—*

(*a*) *Climatic influences*—temperature, humidity, etc.

(*b*) *Conditions relating to the milch cattle, e.g.,* the various diseases of the animals, their housing and tending, etc.

(*c*) *Conditions to be ascribed to the producers, dealers, and vendors of milk, e.g.,* insanitary habits of life, objectionable methods of milking and of storing and transporting milk, communicable diseases of the milkmen, *e.g.*, Tuberculosis, Typhoid, Cholera, etc.

2. Four classes of milk samples were examined bacteriologically in Bombay :—

CLASS I. Samples taken from healthy cows and buffaloes which were specially brought to the Municipal Laboratory. These were collected under the strictest personal supervision and examined immediately after collection.

CLASS II. Samples collected in sterile bottles by the Veterinary Inspectors with ordinary precautions and examined three or four hours after collection.

CLASS III. Samples bought at random from various sources in the City from cattle stables, dairies, railway stations, milk-shops, individual vendors and hawkers. This represents the ordinary market milk of Bombay.

CLASS IV. Samples of pasteurised milk obtained from the Government Military Dairy, Bombay.

3. The milk samples were examined as follows :—

Enumeration of microbes per c.c.

Lactose fermenters in dilutions of 1:10 to 1:1,000,000.

Microscopic examination of the centrifugalised sediment including search for leucocytes, pus cells, streptococci and staphy-

lococci. Examination for Tubercle bacilli including animal experiments. Cultural and other tests for B. Typhosus, Cholera Vibrio, B. Coli communis and B. Enteritides sporogenes.

4. In samples of Class I, the results obtained were almost ideal. The average number of microbes was 396 per c.c.; lactose fermenters were absent in 1 c.c. and less of milk, and the examination for pathogenic microbes was negative in all cases.

5. Sixty-eight samples of Class II were examined with the following results :—

(a) *Microbes per c.c.* (average of 68 samples) were 17 millions.

(b) *Lactose fermenters*: only four samples or 5.9 per cent. showed their presence in a dilution of one in a million.

(c) *Streptococci* were detected only in two samples.

(d) *B. Coli* was detected in 24 samples, or in about 35 per cent.

(e) Examination for other microbes was negative.

These results compare favourably with those obtained in Class III.

6. 240 samples of Class III were examined with the following results :—

(a) *Microbes per c.c.*—The average was about 36 millions.

(b) *Lactose fermenters.*—In 75.8 per cent. samples they were present in a dilution of one in a million.

(c) *Streptococci* were detected in 11.7 per cent.

(d) *B. Coli* was present in 93.7 per cent. Other microbes were absent. These results are extremely bad when compared with those of Class II.

7. 118 samples of Class IV were examined with the following results :—

(a) *Microbes per c.c.*—The average was about 13 millions in the first series, and 7 millions in the second series.

(b) *Lactose Fermenters.*—In 63.5 per cent. of the samples examined they were present in a dilution of 1:100,000, and in 96.6 per cent. in a dilution of 1:10,000.

(c) *B. Coli, B. Enteritides sporogenes, and Streptococci were absent.*

8. These widely different results of the bacteriological examination are mainly dependent on (*a*) the different *conditions of collection and distribution* of the milk samples, (*b*) *the time* elapsing between milking and examination of the samples at the Laboratory, and (*c*) *the temperature* at which the milk samples were held.

9. The favourable results obtained in samples of Class I from a bacterial standpoint show that it is *quite possible to get the purest milk in Bombay,* provided that proper precautions are taken regarding milking, etc.

10. The results of bacteriological examination of samples of Class II indicate that even with ordinary precautions, a great deal of the objectionable contamination of milk can be avoided.

11. As regards the results obtained in samples of Class III, it is quite evident that this means a very *high degree of manurial and other undesirable pollution of the Bombay milk supply.* This series included several samples of milk which were quite genuine as regards their chemical composition, being free from adulteration with water; but a bacteriological examination revealed much contamination with cow-dung and other dirt.

12. The comparatively favourable bacterial results obtained in samples of milk which were pasteurised and then kept constantly at a temperature under 50° F, demonstrate the advantages of pasteurised milk over raw milk.

13. As regards *Tuberculosis,* out of 741 samples of milk examined during four years not a single sample showed the presence of tubercle bacilli. These results have been since confirmed independently at the Bombay Bacteriological Laboratory, Parel. It may be concluded that so far as our present knowledge goes, *Tuberculosis is rarely, if at all, conveyed by milk in India.*

14. The ordinary physical tests used for the determination of dirt in milk (*e.g.*, filtration, sedimentation) are not reliable. The *amount* and *quality* of the dirt present can be ascertained *only by microscopic and bacteriological examinations.* The bacterial content of the milk is an index of the cleanliness of the methods employed in the handling of milk.

15. The above investigation has demonstrated *the practical importance of the bacteriological examination of milk in India.* It cannot be denied that much valuable information can be obtained from a bacteriological examination of milk.

16. As regards *bacterial standards for milk*, it may not be considered desirable at present to adopt them for *legal* purposes, but undoubtedly they would be very useful as guides for *administrative* purposes. Besides, the present bacteriological investigation is probably the first one of its kind in India and further research would be necessary in other parts of the country before a definite standard can be arrived at. In the meantime it is suggested that in the light of the results obtained in Bombay the standard proposed above should be adopted as a provisional measure for Bombay City.

17. In a routine bacteriological examination of milk in Indian cities it is not ordinarily necessary to search for pathogenic microbes, *e. g.*, Tubercle bacilli, B. Typhosus and Cholera Vibrio. The only procedure that is needed is a microscopic examination of the sediment, the bacterial count, an enumeration of the lactose fermenters and the detection of B. Coli.

CHAPTER V.

LOCAL CONDITIONS, DISEASES OF MILCH CATTLE AND OTHER FACTORS AFFECTING THE COMPOSITION, CHARACTER, AND PURITY OF MILK IN BOMBAY AND OTHER INDIAN CITIES.

There are numerous factors which influence the physical character, chemical composition and bacterial content of milk in India, and which must be always borne in mind while attempting to interpret the results of chemical and of bacteriological examination. Many of these have been already mentioned in the foregoing chapters. The principal factors may be classified as follows :—

(1) **Climatic influences,** *e.g.*, seasonal and daily variations, the effects of weather conditions, etc.

(2) **Conditions relating to the milch cattle:—**

(*a*) Heredity and breed ; (*b*) food ; (*c*) housing, tending, etc. ; (*d*) age ; (*e*) period of lactation ; (*f*) diseases of the milch cattle.

(3) **Conditions ascribed to the Gowlees and other milk dealers:—**

(*a*) Customs and habits, *e.g.*, methods of milking, etc. ;

(*b*) Communicable diseases, *e.g.*, Tuberculosis, etc., of the milk dealers themselves.

(4) **Miscellaneous factors** contributing towards contamination of the milk supply during its collection, storage, transportation, and distribution.

(5) **Effects of heat, bacteria, enzymes, etc.**

(1) **Climatic influences :—**

(*a*) **The influence of season** on the *quantity* of milk has been already considered in the previous chapters (q. v.)

(*b*) **The effect of weather conditions on the chemical composition of milk.**—This was studied in Poona by Meggit and Mann.[1] According to them, temperature and humidity have a slight influence on the composition of milk, provided that

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[1] "Memoirs of the Department of Agriculture in India, Chemical Series," Vol. II, Nos. 1 and by A. A. Meggit, B.Sc., and H. H. Mann, D. Sc.

green fodder is available throughout the year as at the Poona Government Dairy Farm. In the case of "Gir" and "Sind" cows, they found that the milk is remarkably constant in composition during the various seasons and that the richest milk (in fat) is reached in the latter part of the rainy season. In the case of buffaloes, they found that the richest milk is obtained in the cold weather and it declines in strength until the rains.

The following figures are given for seasonal variations with regard to fat in buffalo milk[1] :—

	Morning milk (percentage of fat.)	Evening milk (percentage of fat.)
Cold Weather.—		
(November to February)	7.16	8.22
Hot Weather.—		
(March to May)	6.94	7.81
Rains.—		
(June to October)	6.86	7.66

Daily variations.—It has been found by the same observers that there is always a difference in the relative composition of the *morning* and *evening* milk of cows as well as of buffaloes, the evening milk being always richer in fat than that of the morning. In the case of "Gir" and "Sind" cows a difference of nearly one per cent. was found between the morning milk and evening milk. On the other hand, J. Walter Leather found[2] in Pusa, in connection with the Saniwahl (or Montgomery) herd of cows, that the morning milk was usually richer than the evening. These apparently contrary results are probably due to different *intervals* between the times of milking, "morning" and "evening." At Poona the cows were milked between 2 a.m. and 4 a.m. (morning milk), and again between 12 noon and 2 p.m. (evening milk), the periods thus varying from 8 *to* 12 *hours*, while at Pusa *a regular* 12-*hour* interval was allowed between two successive milkings. The difference may be also partly ascribed to the different

[1] Ibid, p. 201, Vol. II, No. 4.
[2] "Memoirs of the Department of Agriculture in India, Chemical Series," Vol. III, No. 6.

breeds of cows whose milk was used for these observations, namely, " Gir " and " Sind " breeds in Poona, and " Saniwahl " or " Montgomery " breed in Pusa.

In Bombay it has been found that in the rainy season there is usually a slight lowering in the percentage of total solids in milk. This is probably due to the green and succulent fodder with which the milch cattle are fed during this time. Otherwise, weather conditions as such do not appear to have any influence on the chemical composition of milk. I have failed to trace any definite connection between the variations in the composition of Bombay milk and the daily meteorological data.

(*c*) **The influence of weather conditions on the bacterial content of milk.**—*Temperature and humidity* are very important factors in the bacteriology of milk. The City of Bombay is situated on an island in 18°55'N and 72°54'E. The island is now permanently connected to a larger island (Salsette) and the mainland by means of causeways and bridges. The climate of Bombay is warm and humid. The average mean annual temperature is 79.6°F., January being the coldest month with an average mean temperature of 73.9°, and May the warmest with an average mean temperature of 84.7°. The average rainfall is 71.15 inches.

The atmosphere of Bombay is usually moist, the lowest humidity occurring towards the end of December and the highest about the middle of July. During the twenty-one months in which a special bacteriological examination was undertaken in Bombay, the average mean temperature was 81.4°F, the average maximum being 86.8° and the average minimum being 76.0°. The average humidity was 0.764 (complete saturation=1.000). The total rainfall during the period was 152.58 inches. It has been found that the majority of bacteria met with in milk grow best at about 25°C. to 35°C. (or 77°F. to 95°F.). At lower temperatures, (15°C. and below), they multiply very little. At higher temperatures different bacteria have their different *thermal death points* (vide figure on page 63). It will be seen that the atmospheric temperature in Bombay corresponds very closely to the most favourable temperature for bacterial growth in milk. This accounts at least partially for the high counts obtained during the hot season. May is the hottest month in Bombay; the average mean temperature during May 1913 was 86.5°F., being the highest during the year. The average count (microbes

per c.c.) of thirty samples of milk examined during this month was over 63 millions, the highest on our records. On the other hand, during February, 1914, when the average mean temperature was lowest, namely 76°F., the average count in twenty-four samples was about 25 millions of microbes per c.c. As regards humidity, the highest point was reached in July 1914 (0.864), while the lowest (0.661) was found in November and December 1914. The corresponding counts, however, do not show such a great difference as in the case of temperature. Temperature seems to be of greater importance than humidity, although it would appear that high temperature with high humidity would be most favourable for the growth of bacteria in milk, (*vide* results obtained in Chapter IV). The weather particulars of 21 months during which milk was examined in Bombay are given below[1] :—

	Temperature in Fahr. Scale.			Humidity complete saturation — 1.000.	Rainfall in inches.	Remarks.
	Maximum.	Minimum.	Average.			
1913.						
April ..	88.9	76.8	82.7	0.761	0.00	Monthly averages of temperature, Barometer Humidity, Wet Bulb Thermometer are derived from observations taken at 6 a.m., 10 a.m., 2 p.m., 4 p.m., and 10 p.m., daily.
May ..	92.0	81.4	86.5	0.723	0.00	
June ..	87.6	79.8	83.7	0.822	25.81	
July ..	84.6	74.5	81.5	0.864	33.58	
August ..	84.9	77.8	81.4	0.815	3.47	
September.	85.4	77.0	81.2	0.827	5.75	
October ..	88.4	77.1	82.7	0.785	2.35	
November.	86.9	73.1	79.8	0.697	0.00	
December.	83.5	69.8	76.6	0.701	0.00	
1914.						
January ..	84.3	69.7	77.0	0.679	0.00	
February.	83.0	69.5	76.0	0.684	0.08	
March ..	84.6	72.0	78.0	0.784	0.00	
April ..	88.0	76.3	82.0	0.747	0.07	
May ..	92.0	81.9	86.5	0.735	0.00	
June ..	89.5	80.7	85.0	0.802	16.69	
July ..	84.8	78.7	82.0	0.866	31.12	
August ..	84.5	77.6	81.2	0.856	12.44	
September.	85.6	78.1	81.5	0.850	21.03	
October ..	90.9	78.6	84.4	0.726	0.01	
November.	90.0	76.3	82.7	0.661	0.18	
December.	85.1	70.2	77.4	0.661	0.00	
Average of 21 months.	86.8	76.0	81.4	0.764	7.26[2]	

[1] These figures were kindly supplied by Dr. N. A. F. Moos of the Government Observatory Colaba.

[2] Total rainfall during 21 months was 152.58 inches.

(2) Conditions relating to the Milch Cattle.

(*a*) **Breed and Heredity.**—The influence of breed has been partly discussed in the previous Chapters. According to the quantity of milk produced the leading breeds of buffaloes are Delhi and Jaffrabadi, while the best cows are Saniwahl, Hansi, Sindhi, and Gir. The Deccani breeds of both buffaloes and cows are poor milkers. As regards quality, it has been found that (both in Bombay and Poona) the milk of Surti buffaloes is richer in fat than that of any other local breed. Meggit and Mann found that Surti buffaloes gave nearly one per cent. more fat in their milk than did the whole herd at the Poona Civil Dairy. As regards cows, it has been already mentioned that the Sindhi and Gir cows yield a higher amount of fat than the other breeds. The half-bred animals from Sindhi cows and Ayrshire bulls yield the largest amount of milk in this country, although the percentage of fat is low.

According to Clouston[1] the best breed of buffalo in India is the Delhi. Given the same ration as a buffalo of the local breed (Central Provinces), a Delhi buffalo will give one-fourth more milk.

The influence of *heredity* in individual families and animals is also important. There seems to be a decided influence from the male parent as well as the female. This is why breeders recommend the breeding of good milch cows only to such bulls of the same breed whose mothers and sisters were or are known to be good milkers. In the same breed, great variations are found in the composition of milk of *individual* animals. This has been shown particularly in the case of Gir and Sindhi cows.[2] This is probably due to the fact that most of the breeds of Indian cows have not undergone any selection for generations.

(*b*) **Food.**—It is a matter of common experience that cattle fed on food rich in proteids and fats will yield milk of a superior quality, particularly with regard to fat. This is why cotton-seed, "chuni" (husk of *Cajanus Indicus*), and oil cakes form a part of the daily ration of the milch cattle in Bombay. Animals fed only on green and succulent fodder yield milk which is rather poor in fat and total solids, but the total quantity is appreciably increased. The kind of food given seems to influence the chemical composition of the milk to a greater extent than even the breed

[1] Jour. of Dairying, Vol. I, Part 3, p. 219.
[2] "Memoirs of the Department of Agriculture in India," Vol. II, No. 1, pp. 33 and 35.

of the animal. Take for instance a fine Sindhi cow with full udders and feed it on food poor in fat and nitrogenous matter; the milk will remain poor in quality in spite of the good breed.

The approximate daily feed of milch cattle in Bombay[1] *is given below*:—

	Chuni (Husk of "Cajanus Indicus.")	Cotton seed.	Bajri.	Husk of Toor Dal.	Wheat Bran.	Oil Cake.	Hay.
	lbs.	lbs.	lb.	lbs.	lbs.	lbs.	lbs.
Cows ..	4-5	1½-2	½	4½-8	½-1	½-1	10 to 15
Buffaloes.	5-10	2-4	1	5½-11	¾ to 3½	½-3	10-18
				Rice chaff 3—5			

The amount of fat in the milk of cattle fed with the above ration varies from 5 to 11½ per cent. according to the kind and amount of feed. Mr. Frost, the Hon. Secretary of the Dairy Education Association, Poona, mentions the following feed which is usually given in three classes by the best dairy farmers :—

1*st class*.—2 lbs. bran, 2 lbs. oil meal, 2 lbs. gram, 10 lbs. cotton-seed hulls, 20 lbs. dry fodder or 50 lbs. of green maize and sorghum stalks, good hay and "bhoosa" being the chief.

2*nd class*.—2 lbs. bran, 2 lbs. oil meal, no gram, remainder the same as Class I.

3*rd class*.—1 lb. bran, 2 lbs. oil meal, no gram, 5 lbs. hulls, fodder same.

The following statement shows the daily ration issued to milch cattle on the Government Military Dairy Farm at Peshawar :—

Daily ration for cows (*Saniwahl breed*):—

Grain and Fodder.	Quantity in lbs.	Composition.			Remarks.
		Albumenoids.	*Carbohy-rates.*	*Fat.*	
Gram	4	.72	2.31	.21	Albumenoid ratio for cows' ration. 1 : 5·4
Bran	4	.52	2.33	.14	
Mustard-Oil cake ..	2	.65	.60	.16	
"Bhoosa" (Wheat and Barley.) ..	10	.10	3.79	.09	
Dry "Churri" (Millet)	4	.17	2.04	.04	
"Khasil" (Barley) ..	25	.54	1.91	.10	
Salt	1½ oz.	..	..	..	
Total ..	..	2.70	12.98	.74	

[1] This is the average taken from the figures supplied by the Chief Veterinary Inspector Bombay.

Daily ration for buffaloes :—

Grain and Fodder.	Quantity in pounds.	Composition.			Remarks.
		Albumenoids.	*Carbo-hydrates.*	*Fat.*	
Gram..	4	.72	2.31	.21	Albumenoid ratio for buffaloes' ration, 1:5.5.
Bran	4	.52	2.33	.14	
Mustard-Oil Cake ..	2	.65	.60	.16	
"Bhoosa" (Wheat and Barley) ..	10	.10	3.79	.09	
"Churri" (Millet)..	5	.21	2.55	.05	
"Khasil" (Barley).	30	.64	2.36	.12	
Salt	1½ ozs.	..	..	..	
Total ..	..	2.84	13 94	.77	

On the above rations the cows yielded from 3.8 to 4.7 per cent. fat, and the buffaloes from 5.9 to 7.5 per cent. fat. The non-fatty solids did not show much variation. The question of Feeding Standards will be discussed in Chapter VII (q.v.).

(*c*) **Housing, tending, etc., of the milch cattle.**—The milch cattle in India are kept in stables or sheds which are usually put up in any way with entire disregard to sanitary requirements. A typical cattle stable in Bombay has been described on page 24. The close proximity of the cattle stables to human dwellings, the inadequate provision for the speedy disposal of stable refuse and cow-dung, the lack of ventilation and of sufficient light and the defective supply of water, etc., are some of the main factors which are responsible for the pollution of the milk supply. The insanitary condition of the milch cattle stables has a direct bearing on the bacterial content of milk, as has been shown in Chapter IV. Proper tending of the animals has an important bearing on the amount of milk produced. For instance, it has been found that in large commercial dairies there is a tendency for the yield of animals to fall off gradually due to careless tending.

(*d*) **Age.**—The best age for Indian milch cattle for the maximum yield of milk is from five to eight years. There is very little change in the quality of milk until the animals begin to show senile decay, when the milk gets poorer as the animal gets aged.

(*e*) **Period of lactation or time of calving.**—The length of the lactation period varies a great deal in different animals and sometimes even with the same animal. It is a common observation that from the time of calving to the time of "drying up," that is during the period of lactation, there is a definite relationship between the yield and the composition of milk, namely, that as the quantity diminishes the richness of milk increases proportionately. Thus, it has been observed at a Government dairy farm in North India that the milk is largest in amount and poorest in quality just after calving. It gradually gets richer as the lactation period advances and the quantity diminishes. The experience of other observers seems to be somewhat different. It has been observed in Poona, for instance, that in some breeds, such as Sindhi cows, there is a tendency to an increase in the fat content of the milk as the lactation progresses. On the other hand, in the case of Gir cows and the Surti buffaloes there seems little relationship between the composition of milk of individual animals and the yield, except that the milk becomes slightly richer at the end of the period of lactation.[1]

(*f*) **Diseases of the milch cattle.**—The commonest diseases prevalent in Indian milch cattle are *Foot-and-Mouth Disease and Rinderpest.* Then there are *diseases of the udder,* such as the different varieties of *Mastitis* which affect the quality of milk.

Foot-and-Mouth Disease usually visits every herd in India about once a year, but owing to its frequency it is remarkably mild. It is not so fatal in India as it is in Europe. Imported stock suffer very much and many succumb. It appears mostly amongst young stock. Milch cattle suffering from this disease usually dry off completely, the milk gradually coming back after recovery. Foot-and-mouth disease is known to be conveyed to man through the milk.

Rinderpest is the disease most feared, and many farms are visited with an epidemic once a year, more or less; others escape for three or four years. In Northern India it is reported to appear every second year with great regularity. There is usually a cessation of milk in cattle suffering from Rinderpest, and in severe cases the milk may not return to the normal for a year after recovery.

[1] Meggit and Mann, "Memoirs of the Department of Agriculture in India," Vol. II, No. 1, p. 36; Vol. II, No. 4, p. 232.

Mastitis (*Mammitis* or *Garget*) is a common complaint in Indian cattle. In the severe forms there is a good deal of harm done to the udders; in some cases the affected cows have been known to lose an entire quarter or even two quarters. The milk from the affected quarter appears watery and there may be a change in the color (yellow to light brownish). A microscopic examination of the sediment usually shows leucocytosis, pus cells and streptococci. Such milk has a salty bitter taste. The chemical analysis usually indicates a marked decrease in the amount of total solids, particularly in the amount of fat. The milk-sugar is also considerably diminished. There is a slight increase in the amount of proteids. The specific gravity in most cases is low. On the whole the changes in the chemical composition suggest adulteration with water.

Piroplasmosis is generally fatal to all English stock unless protected by serum. The country stock are usually immune.

Anthrax.—During the course of this disease the secretion of milk falls off suddenly. According to Monatykows,[1] the percentage of sugar and fat is increased and the albumen decreased. According to the investigations of Jensen and others, the milk of cows affected with Anthrax very frequently contains virulent bacilli. Hence the milk of such animals may be considered dangerous to health.

Bovine Tuberculosis.—There are only a few statistics available with regard to the prevalence of tuberculosis in Indian milch cattle.

A brief investigation regarding bovine tuberculosis was made in Bombay in 1911. The *Tuberculin* test was tried in the case of several cows and buffaloes by the Veterinary staff of the Public Health Department, Bombay, and reported on by the Health Officer.[2] According to this report, five cows gave the reaction, but when reinoculated with Tuberculin only one animal responded. The following table gives the details of these tests :—

[1] *Jensen's Milk Hygiene*, by Pearson, 1909, p. 90.
[2] *A report on how Tuberculosis is spread in India*, by Dr. J. A. Turner, M.B., D.P.H., Executive Health Officer, Bombay, 1911, *Times Press, Bombay*, pp. 23-28.

[TABLE.

"Statement of Cows inoculated with Tuberculin for the second time as compared with first inoculation results."

Description of the Animal.	Date of inoculation and re-inoculation	Temperature before inoculation.	Temperature after 13 hours.	Temperature after 15 hours.	Temperature after 17 hours.	Result.	Remarks.
White (A).	13th July 1910	102°	$\frac{8}{104.2^\circ}$	$\frac{14}{103.6^\circ}$	..	+	Out of five cases, only one case had reaction for the second time which was not so strong as at the first time. All the remaining four cases had no reaction for the second time.
„ ..	30th Octr. „	103.8°	102°	102°	102.2°	—	
Black ..	13th July „	101.2°	$\frac{10}{103.6^\circ}$	$\frac{14}{104^\circ}$	..	+	
„ ..	30th July „	102.8°	102.2°	101.6°	102°	—	
Red ..	26th July „	101°	$\frac{10}{102.4^\circ}$	$\frac{14}{105.6^\circ}$	..	+	
„ ..	30th Octr. „	102.8°	101.2°	101.2°	101.4°	—	
White (B).	20th Octr. „	103°	105.4°	105.7°	105.6°	+	
„ ..	5th Novr. „	103°	103.2°	103°	103.4°	—	
Iron Grey..	20th Octr. „	103°	104.2°	105.4°	106°	+	
„ ..	5th Novr. „	102.8°	102.8°	104°	104.6°	+	

"Statement of Buffaloes tested with Tuberculin at the milch cattle stable, No. 1-2, Forjett Street Cross Lane, on 28th September, 1910."

Serial No.	Temperature before inoculation.	Temperature after 12 hours.	Temperature after 15 hours.	Temperature after 18 hours.	Remarks.
1 ..	102.4°	102.4°	101.4°	102.2°	
2 ..	102.2°	102°	101.4°	102.6°	
3 ..	102.4°	102.2°	102°	....	The animal would not allow the test, as it was milking time.
4 ..	102°	102°	102.2°	....	
5 ..	103°	101.8°	102°	103.6°	
6 ..	103°	101.6°	101.8°	102°	
7 ..	102.2°	101.2°	101.6°	102°	
8 ..	101.4°	101.4°	101.4°	101.6°	
9 ..	102.4°	101.8°	103°	102.8°	

During the course of this investigation thirty cows "looking suspicious of Tuberculosis" were selected for examination. Tubercle bacilli were found in the organs of only one animal that was brought for slaughter[1] to the Bandra Slaughter House. In a few suspected cases a post-mortem examination was made with negative results. In the case of buffaloes the Tuberculin injections always gave negative results.

Several hundreds of samples of milk were examined by the writer during a period of four years in Bombay, but tubercle bacilli were not detected in a single case.

From these investigations it is evident that *Tuberculosis is extremely rare among cows in Bombay*, it has *never been found in buffaloes*, and Tubercle bacilli have *never been detected in Bombay milk.*

Mr. Donald, Manager, Government Military Dairy Farm, Peshawar, reports that during seven years twelve cases of bovine tuberculosis occurred in a herd of 300 cows. The diagnosis was made by clinical signs. Out of the twelve animals three reacted to Tuberculin and were destroyed. Milk from these animals was not, unfortunately, examined for tubercle bacilli.

A systematic investigation has been made recently by Dr. A. Lankester, who has been specially deputed by the Government of India for tuberculosis inquiry. The following is a brief summary of Dr. A. Lankester's investigation[2] :—

Bovine tuberculosis has been found in Cawnpore and more recently in cattle at Ferozepore and at Simla. The cases from Ferozepore and Simla were examined by Captain Acton, I.M.S., and Mr. G. Taylor of the Veterinary Department. They were undoubtedly cases of tubercular disease—in every instance affecting the lymphatic glands. One or two cases have also recently been reported from Lahore.

As regards Madras, Dr. Nield Cook failed to find a single case of tuberculosis out of many thousands of carcases examined. Major T. S. Ross, I.M.S., when Health Officer in the same city, also failed to find any sign of tuberculosis in a single organ or any trace of external tubercle of the udder in a large number of cows examined in the cattle sheds. Dr. F. M. Gibson, Director, King Institute of Preventive Medicine, Madras, has never seen a case

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1 *Vide* footnote 2 on page 85.

2 Dr. Arthur Lankester, (on Special Duty for Tuberculosis Inquiry, Government of India) in a personal communication.

of bovine tuberculosis in India and has had no certain evidence that would lead him to believe that it exists in South India. Similar negative evidence has reached Dr. Lankester from Assam, Bihar and Orissa and from the Muktesar Veterinary Laboratory regarding the cattle of the Kumaon Hills. Dr. Nield Cook was able to obtain evidence of 31 cases occurring amongst over 4,000 cattle at the Bengal Veterinary College Hospital between 1893 and 1903, and 21 cases between 1900 and 1902 amongst thousands of cattle at the Government Cattle Farm, Hissar, Punjab. It is, of course, quite possible that these very exceptional cases occurring entirely in Northern India, where cattle and human beings are frequently crowded together in the same dwellings, may be the result of infection from human sources. The type of the organisms found in these cases has not yet been definitely established. As regards its prevalence in buffaloes and its transmission to man, Dr. Lankester says :—

"The disease so far has been found only in cows. I have not heard of a single case in which tuberculosis has been found in buffaloes.

"Tuberculosis in man has, I believe, never been directly traced in India to tuberculosis in cattle.

"I do not believe that tubercle bacilli have ever been detected in any contaminated samples of milk. Your own examinations have been the most extensive of any that I have heard of in India into this matter."

The rarity of bovine tuberculosis in this country may be partly ascribed to the fact that, in India, cattle are usually allowed to graze out in the open air and in the sunshine to a greater extent than in Europe or in America.

(3) **Conditions ascribed to the Gowlees and other dealers of milk.**

(*a*) *Customs and habits.*—The average milkman in this country has no idea of cleanliness. He is entirely callous as to whether the animals are properly scrubbed and washed before milking or not, or whether the vessels used for milking are clean or otherwise. He is dirty about his own person and takes no trouble to see that his hands are perfectly clean before milking. *The method of milking in India* is peculiar in many respects (see Plate XXI). The animals are milked in the same place where they are tethered. Milking time is usually the feeding time also, and, as a rule, the cattle will not give proper milk unless they

are fed at the same time. This is probably the result more of habit than a characteristic of Indian cattle. In Bombay, the animals are milked twice a day—between 2 and 4 a.m., (" morning " milk) and between 12 noon and 1 p.m., (" evening " milk). It has been already pointed out that there is a slight difference in the composition and yield of milk—'morning' and 'evening.' *The period of time elapsing between two milkings* affects both the yield as well as the percentage of fat. Leather found that when the intervals between the milkings are very unequal the quantity of milk given is usually greater and the fat percentage less after the longer period. On the other hand, when the intervals between the milkings are equal, the yield of milk and percentage of fat remain practically constant. These observations have been recently confirmed by me in a series of milk samples examined from the same animals (buffaloes and cows) in a cattle stable in Bombay. Another custom which is almost universal in India is to allow *first the calf* to have milk from its mother and then to begin milking. The amount consumed by the calf being an unknown quantity, the figures usually obtained for the total yield of milk per day or per lactation are somewhat erroneous. Leather in 1911-1912 made very careful observations on this question in connection with the Saniwahl breed of cattle at Pusa[1]. He was able to measure the yield accurately by allowing the calf to suck one half of the udder only, whilst the other half was entirely hand-milked. It was found that the calf actually took one-half of the total milk.

There are many customs and beliefs prevalent among milkmen in this country. For instance, it is the custom in nearly every household to have the milk heated or boiled before use. From a bacterial point of view this is a very good custom. In connection with this, however, there is a 'religious' belief that addition of water is necessary before heating the milk or else it would have an untoward effect on the health of the animal concerned !

Milk is collected usually in brass vessels of different sizes, (Plates XXII and XXIII). It is rare to find the udders and flanks of the animals quite clean. The domestic habits of most of the milkmen are proverbially dirty. Most of them live in close proximity to the filthy cattle stables and are supremely deaf to all laws of personal or public hygiene. It is well known that

[1] "Memoirs of the Department of Agriculture in India, Chemical Series," Vol. III, No. 6.

cowdung is used for various purposes in India. For instance, the mud-floors of the dwellings are very frequently covered over with a thin layer of cowdung which is supposed to give a clean appearance to the floor! This is another possible source of pollution.

(*b*) *Communicable diseases, e.g.*, Tuberculosis of the milk dealers themselves. It is not uncommon to find a case of Pulmonary Tuberculosis (Pthisis) among the milk dealers. A few such cases have been recently reported in Bombay by Dr. C. Coutinho.[1] Considering their habits of life, the ill-ventilated dwellings, the unhygienic surroundings, and the careless manner of handling milk, this is not at all surprising. In 1911 the author examined 271 samples of sputum for tubercle bacilli. These samples were collected from milch cattle stables, milk-shops, washing places for cows and buffaloes, and the roadside. Out of the 271 samples examined, 33 contained tubercle bacilli, giving 12 per cent. for the infected samples. There are many possibilities of contamination of milk *after* it has been drawn.

Other diseases such as Cholera, Epidemic Diarrhœa, Typhoid fever, Dysentery, Diphtheria, etc., are likely to be transmitted by persons employed in the milk trade. Cholera and Typhoid "carriers" are by no means rare in India.

(4) **Miscellaneous Factors contributing towards the contamination of the milk-supply during its collection, storage, transport and distribution.**

Many of these—particularly with regard to collection and transport—have been already mentioned. After the milk has been collected under the very worst conditions imaginable in a filthy stable from a dirty and sometimes diseased animal into an unclean vessel by a person with unwashed hands, and whose sneezing, coughing, spitting, and nose-blowing operations contribute a further generous quota of undesirable and often pathogenic-microbes to the milk, it is now transported through the insanitary and crowded city streets in a most primitive manner. The milk-vessels are (1) carried over the head or shoulders, (Plate XXII), or (2) suspended from a pole (usually made of bamboo) by means of strings and then slung across the shoulders (Plate XXIII), or (3) conveyed in the slow suburban trains in the manner previously described, or (4) very rarely in milk cans

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[1] **Half-yearly Report of the Medical Officer, King George V. Anti-Tuberculosis League, Bombay, July 1915.**

with proper covers and conveyed by a modern milk-waggon (Plate XXIV). After reaching the house of the consumer, the milk is measured out with a small measure (usually quarter of a seer=6 ozs.) which is not provided with a handle. This is dipped along with the dirty fingers into the large milk container every time that a certain amount of milk is to be measured out to the customer. Most of the dairies provide the milk vessel with a tap at the lower end and a lock which secures the cover at the top. This arrangement is believed to prevent any tampering with the contents by the milk vendor. Milk bottles are very rarely used in India. The manner in which milk is conveyed to the city from the suburbs has been already described in Chapter II.

The various sources of pollution may now be summarised :—(1) From the udders and flanks of the animal. (2) From Mastitis and other diseases of cattle. (3) From dirty hands and clothing of the milker. (4) From diseases of the milkmen, *e.g.*, tuberculosis. (5) From milk vessels. (6) From insanitary cattle stables. (7) During transportation. (8) From dirty water used for adulteration. (9) At the time of distribution ; and (10) Careless handling at the residence of the consumer.

(5) **Effects of Heat, Bacteria, Enzymes, &c.**

(*a*) **Action of Heat.**—Milk is a very unstable liquid. This is mainly due to the presence of proteids and milk-sugar. When milk is heated a film or pellicle forms on the surface. This is believed to be caused by the drying and coagulation of a part of the proteids which the milk contains.[1] The scum consists largely of caseinogen[2] and fatty matter. When milk is boiled there is a decided change in its taste and odour. This is probably due to the decomposition of some of the proteids with the liberation of hydrogen sulphide (H_2S) or some other volatile sulphide.[3, 4] It appears that in boiled milk there is a partial precipitation of calcium salts in the form of tri-calcium phosphate.

At high temperatures, milk is coagulated by the action of heat. Bardach[5] found that about twelve hours heating at 100°C. was required in order to bring about coagulation of fresh milk, whereas at 130°C milk coagulated in one hour, and at 150°C in three minutes.

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1 Jamison and Herty, *Jour. Physiol*, 1901. No. XXVII, pp. 26-30.
2 Rettger, *Amer. Jour. Physiol*, 1902. No. VII, pp. 325-330.
3 Rettger, *Amer. Jour. Physiol*, 1902. No. VI, pp. 450-457.
4 Franz. *Utr. Milch Zeit*, 1903, pp. 32,354-355.
5 Bruno Bardach. *Monatshefte*, 1897, pp. 18,199-216.

Another important change in milk effected by heat is the destruction of micro-organisms. Advantage is taken of this in pasteurisation, boiling and sterilisation of milk. Heat above 70°C—75°C kills the ferments in milk.

The changes produced in milk by heating depend generally upon (1) the degree of heat, and (2) the length of the exposure. *Pasteurisation* consists in heating the milk usually at 60°C (140°F) for twenty minutes to be followed by rapid cooling (Rosenau). Others recommend a temperature of 63°C (145°F) or 150°F for 30 minutes. Pasteurisation does not appreciably affect the chemical and physical properties of milk. *Boiling*, as already mentioned, is believed to produce profound changes in milk, such as decomposition of the proteids and other nitrogenous derivatives; increase of inorganic phosphorus and decrease of organic phosphorus; precipitation of calcium and magnesium salts; coagulation of serum albumen; caramelisation or burning of milk-sugar, etc. The casein is rendered less easy of coagulation by rennin and hence imperfectly acted upon by the digestive ferments.[1] *Sterilisation* of milk consists in heating it at a temperature of 120°C for 15 minutes.[1] Other temperatures [*e. g.*, 100°C (212°F) for 40 minutes] are also recommended. This would result in the destruction of all microscopic life. Chemically, the changes are more profound than in the case of boiling. The milk assumes a brownish colour through caramelisation of the milk-sugar and the lecithin content of the milk diminishes. The proteids change into peptones, and tricalcium phosphate is precipitated. This is considered to be the cause of the retardation of the rennin coagulation of milk. Lörcher[2] observed that cooked milk coagulates with rennin more slowly than raw milk. According to Rubner[3] and Middleton,[4] the lactalbumen is coagulated by heating at 100°C for a short time. De Jager[5] concludes that caseinogen is more readily digestible than casein, and hence the digestibility of milk is diminished by cooking. It is a well-known fact that the enzymes or ferments in milk are killed by heat. Between 65°C and 70°C most of them are weakened in their activity, and between 70° and 80°C all of them are destroyed.[6]

Rosenau. *The Milk Question.*
Lörcher: *Pflug Archiv*, 1897, p. 99.
Rubner. *Hyg. Rundschan* 1895, No. XXII, pp. 1021-1022.
Middleton. *Ibid* 1901. No. XI, p. 601.
De Jager. *Cent. f. Med. Wissenschaft*, 1906. No. IX, p. 145.
Pub. Health, and Mar, Hosp. Serv. U. S. A. *Hyg. Lab. Bull.* No. 56, p. 338.

These changes are believed to interfere seriously with digestion and nutrition. Other observers like Variot[1] and Forbes-Ross[2] prove to the contrary that heat exerts no deleterious effects on the digestibility of milk. This point will be discussed fully in Chapter VI.

(*b*) **The action of Bacteria, Moulds, etc.—**

It is a common experience that when raw milk is left alone, after some time it turns sour and curdles. This is due to *fermentation* (in which the starches and sugars are broken down) brought about by lactic acid bacteria. Besides fermentation, milk may undergo *putrefaction*—by which is understood particularly the breaking down of nitrogenous substances in milk. The end products of fermentation are acids and alcohol, while those of putrefaction are usually called ptomaines. Fermented milk is acid in reaction and shows the *curd* which consists of precipitated casein. Putrid milk has an alkaline reaction and an unpleasant taste and odour. *Lactic acid fermentation* is practically the change of milk-sugar into lactic acid under the influence of a series of micro-organisms most of which are of the *bacillus acidi lactici* type.[3]

Lactic acid bacilli are important from an economic point of view as they assist in the preparation of butter and cheese. The beneficial effects of soured milk are well known. As regards the relation of lactic acid bacilli to pathogenic bacteria in milk, our knowledge is very incomplete. From the experiments carried out by the author, it appears that they and their products are inimical to the growth of pathogenic bacteria in milk, so that in themselves lactic acid bacilli may be considered harmless.

Under certain conditions milk may become infected with a variety of bacteria which bring about great changes in its appearance, composition, odour and taste. Some of these changes will be now briefly mentioned.

Blue milk.—This is usually caused by ***bacillus*** *cyanogenes* or *Bacterium cyaneofluorescens* (Zangemeister). The organism was isolated by Hueppe and Engling.[4] While blue milk is considered to be apparently harmless, its occurrence indicates external contamination. If it has been traced to any particular

[1] Variot. *Comp. rend. des Seances de l' Acad. d-Sci.* Vol. 139, 1904, p. 1002.
[2] Forbes-Ross. *Lancet,* 1904, pp. 979-980.
[3] Conn. Fifteenth Ann. Report, Storr's Agr. Exp. Stat. 1903, p. 92.
[4] Hueppe and Engling, *Bied. Centr.* 18 and 5, pp. 414-415.

animal its production can be prevented by washing the teats with a little dilute acetic acid.

Yellow milk.—Yellowish colour is not uncommon in milk from Indian cows. Such an appearance should be considered physiological in the case of cows' milk in India.

Red milk.—This is ordinarily due to the presence of blood in the milk. The blood may come from an injury or acute inflammation of the udder. Sometimes a reddish colour may develop in milk as a result of feeding the animals on plants containing red pigment. Occasionally a red colour may be produced by bacteria, *e.g.*, *bacillus erythrogenus, bacillus prodigiosus*, and others.

Other colour changes in milk.—Other changes are somewhat rare and are produced by pigment-forming bacteria. According to Conn,[1] bacteriologists have described milk of the following colours: yellow, orange-coloured, green, amber-coloured, indigo, chocolate-coloured and black. Ernst[2] describes brown milk and milk with gray, green fluorescent and violet spots.

Slimy or ropy milk.—Under certain conditions mucilaginous substances develop in the milk as a result of the growth of certain bacteria, *e.g.*, the *bacillus lactic viscosis*. The milk acquires a characteristic ropiness and can be often drawn out into long threads of exceeding fineness. Slimy milk may be the result of mucopurulent discharges caused by various forms of Mastitis (Garget), etc.

Bitter milk.—Freshly drawn milk has sometimes a bitter taste; sometimes such taste is developed after standing for a few hours. The former may be due to passage of certain substances into the milk from the food of the animal, such as lupine, wormwood, turnip, cabbage, etc. In the latter case the bitter taste is caused by certain micro-organisms.

The principal factors relating to the milch cattle, etc., are summarised below:—

(*a*) *Breed and Heredity.*—The Indian cows generally, all things being equal, are fairly constant in quality, but when bred with English bulls the milk of the progeny shows a diminution in fat and non-fatty solids. The former may run down to 3.8 %.

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1 Conn. *Agricultural Bacteriology.* Philadelphia, 1901, p. 205.
2 Wm. Ernst. *Text Book of Milk Hygiene.* 1914, p. 178.

(*b*) *The Seasons* affect the *quantity* more than the *quality* (as already pointed out in Chapter III), except immediately after the commencement of the monsoon the quality drops owing to the young grass and the cold nights.

(*c*) *Temperature.*—Cattle exposed to excessively low temperature suffer in quality of milk, but this exposure is not reached in India except in the hills and in the extreme north. Anything below 40°F would cause a loss in quality and in quantity.

(*d*) *Foods* influence both the quality and the quantity. By the substitution of green and succulent fodder for the dry one the quantity goes up considerably but the quality suffers.

(*e*) *Period of Lactation.*—There is a great variation in milk towards the end of lactation when the quantity is very low.

(*f*) *Age.*—There is little change in quality of milk until the animals begin to show senile decay.

(*g*) *Disease.*—Cattle suffering from disease usually stop milking at once, the only exception perhaps being tuberculosis. *Tuberculosis among Indian cattle is very rare,* except on the hills and in some parts of North India. Other diseases of milch cattle are *Foot-and-Mouth Disease, Mammitis, Rinderpest, Piroplasmosis and Anthrax.*

CHAPTER VI.

THE RELATION OF MILK TO THE PUBLIC HEALTH, INCLUDING INFANT MORTALITY IN INDIA, AND THE "BIOLOGICAL PROPERTIES" OF MILK.

From the researches mentioned in Chapters III and IV, among many others the following facts have been established :—

1. *That the adulteration of milk in Indian Cities is very common, reaching about* 80 *per cent. in Bombay, Poona and Bangalore.*

2. *That the city milk supply shows a high degree of contamination with objectionable bacteria.*

The addition of water to milk is not only a fraudulent practice, but is also a menace to public health. Adulteration of milk with water may affect health *directly* as well as *indirectly*. The water used for adulteration by the milk-dealers in India is usually *impure* bacteriologically and *unfit* for drinking purposes from a chemical point of view. It is often drawn from the insanitary wells near the cattle stables, (*vide* Plates XXVIII and XXX). The water from such wells is usually loaded with B. Coli and allied organisms, and chemical analysis almost invariably indicates organic pollution with sewage, etc. As milk is an excellent culture media for the growth of bacteria, the introduction of a few pathogenic microbes through the addition of impure water will result in an enormous and rapid multiplication of such bacteria in milk. In this way the adulterated milk may be the means of disseminating widely various infections, *e.g.*, Cholera, Typhoid, etc. Several cases of Cholera in Calcutta were traced to such a source.[1] The author isolated Cholera Vibrio from two wells in Bombay in 1912. Health is affected *indirectly* by the addition of water to milk. The effect of watering is to alter the physical and chemical properties of milk. This may lead to malnutrition and improper feeding, particularly in the case of children, frequently causing Rickets, Debility, etc.

Contamination of milk with pathogenic microbes and its significance have been briefly discussed in Chapter IV. It is a

[1] *The Practitioner*, Vol. XXXIV, p. 144.

well-known fact that milk is frequently a vehicle for the transmission of infectious diseases to man. The ingestion of impure milk also often leads to gastro-intestinal and other disorders of various kinds. A few of the principal milk-borne diseases will be dealt with here, and the question of infant feeding and infant mortality with reference to the milk supply will also be briefly discussed. Among the disorders and diseases that may be caused by bad milk are Diphtheria, Rickets, Foot-and-Mouth Disease, Scarlet Fever, Malta Fever (through goats' milk,) Milk Sickness (in the U. S. A.), Sore-throat and Tonsilitis, Typhoid Fever, Gastro-Intestinal disorders including ordinary Diarrhœa and Dysentery, Epidemic Diarrhœa, Tuberculosis, Cholera and Milk Poisoning (Galactotoxismus.) The most important of these that affect us in India are Cholera, Typhoid, Gastro-Intestinal Disorders, different varieties of Diarrhœa and Tuberculosis.

Diphtheria.—Epidemics have been traced to milk in Europe and in the United States of America. It is not known to occur in epidemic form in this country, although a small number of scattered sporadic cases have been observed from time to time. The author examined samples of milk in connection with a few cases of Diphtheria in Bombay, but was not able to find the specific micro-organism. These results seem to suggest that, in Bombay at least, milk does not play a very important part in the spread of Diphtheria.

Rickets.—As regards its prevalence, no records are available. It is believed, however, that many cases of Rickets in children are indirectly caused through ingestion of bad milk.

Foot-and-Mouth Disease is transmissible to man through ingestion of the raw milk of an animal suffering from the disease. The virus of this disease is ultra-microscopic and is readily killed by exposure for twenty minutes at a temperature of 60°C. In this country, milch cattle suffering from Foot-and-Mouth Disease very soon stop milking. No reliable statistics are available in India regarding the prevalence of this disease in man.

Scarlet Fever and Malta Fever (*through goats' milk.*).—These are really clinical rarities in India.

Milk Sickness.—This disease is endemic only in the United States of America. It is described as an acute, non-febrile disease, probably of a specific nature due to ingestion of milk, milk products, or the flesh of animals (usually cattle) suffering from a disease known as *trembles.* The disease in man is

characterised by great depression, persistent vomiting, obstinate constipation, and high mortality.[1]

Sore-throat and Tonsilitis.—Stokes and Wegefarth,[2] Beck,[3] Lameris and von Harrevelt,[4] Kenwood,[5] Savage[6] and many others record epidemics of sore-throat with cervical adenitis, colic, diarrhœa and fever, which were ascribed to the use of milk from cows suffering from Garget or Mastitis. Such milk when examined was found to contain pus and streptococci in great abundance. Septic sore-throat is well known in Great Britain and in the U.S.A. Many outbreaks in these two countries are on record.[7] Most of these epidemics were traced to milk infected with a streptococcus. In India no such epidemics are on record. Streptococcic sore-throat is, however, not uncommon in Bombay and other Indian Cities, and it may be partly traced to the presence of streptococci in milk.

Typhoid or Enteric Fever.—Epidemics of typhoid fever caused by infected milk have been reported from time to time in Europe and America. Milk is a very inportant vehicle for the spread of enteric fever. Harrington[8] records that out of eighteen epidemics of typhoid fever investigated by Massachusetts State Board of Health, fourteen were milk-borne, only three being water borne and one of unknown origin. The typhoid bacillus grows well and multiplies rapidly in milk without producing any appreciable change in its colour, odour, taste or appearance.[9] Hence the danger is insidious. There are many ways in which milk may become infected with typhoid bacilli. A very important method of spread is by means of "carriers." Such "carriers" are by no means uncommon in the large cities. A "carrier" excreting the bacilli in his or her stools or urine could very easily contaminate a milk-supply either at the source, during milking and storage, or during its transit and distribution. Many outbreaks of typhoid have been traced to "chronic carriers." In September and October, 1908, Lumsden and Woodward reported [10] an outbreak in Washington, D.C., in which fifty-four

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1 Hyg. Labs. Bull. No. 86, U.S.A. *Vide* Rosenau. "The Milk Question," for outbreaks in America.
2 Stokes and Wegefarth. *Medical News*, 1897. Vol. 71, No. 2, p. 45.
3 Beck. *Deutsches Vierteljahrschr, f. offentl. Gesundheitspfl.* Heft, III, § 430.
4 Lameris and von Harrevelt, *Zeitschr, f. Fleisch, u. Milch Hyg*, 1901, Bd. II, §. 114.
5 Kenwood. *British Med. Journ.* 1904, No. 1, p. 602.
6 Savage. *Journ. of Hyg.* 1906, Vol. VI, p. 123.
7 *Vide* Swithinbank and Newman. "Bacteriology of Milk," for outbreaks in Great Britain.
8 Harrington. *New York Medical Journal*, 1907, LXXXV, p. 696.
9 Rosenau. "The Milk Question," p. 113.
10 *Journal of American Medical Association*, Vol. LII; pp. 749-752

cases occurred. This was traced to a farm supplying the milk. No history of any recent illness in the farm could be ascertained, although all the evidence pointed to the milk-supply of this farm being responsible for the epidemic. A search for bacillus carriers was made among the milkers and typhoid bacilli were detected in the fæces of a woman who had had typhoid fever eighteen years previously! Scheller [1] traced a typhoid epidemic near Königsberg, Germany, to a woman "carrier" who had an attack of enteric fever seventeen years before.

The *isolation of the typhoid bacilli from milk* is extremely difficult. Some investigators are said to have been successful in doing it. According to Ernst,[2] Konradi positively demonstrated typhoid bacilli in milk. Shoemaker[3] of Philadelphia also claims to have isolated the typhoid bacillus in a milk-borne epidemic in 1906. In Bombay 316 samples of milk obtained in connection with cases of typhoid fever were examined by me with negative results.

As regards milk-borne epidemics of typhoid in India, from numerous enquiries made, I find that there is practically no scientific evidence on record for tracing any outbreaks to milk. In Calcutta and in Bombay several attempts have been made, in the case of small outbreaks of enteric fever, to find out any relationship between the cases and the milk supply, but in nearly every instance it was found impossible to trace the milk supply to its actual source. From what has been said in Chapter II regarding the sources of the milk supply of Indian cities, it is evident how extremely difficult is the task of following up any particular milk supply to its actual source and examining it for "carriers." Adulteration with filthy water is very common in this country as already pointed out. Water infected with typhoid bacillus when added to milk would constitute another way of conveying the infection through milk.

It has been suggested that milk-borne epidemics of enteric fever may be caused by the milch cattle drinking water contaminated with typhoid bacilli, the bacilli afterwards being excreted in their milk. This seems to be rather far-fetched and there is no evidence in favour of this suggestion. There is, however, every possibility of the udders being contaminated by the animals standing in the water infected by typhoid bacilli.

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[1] *Cen:blt. f. Bakt.* Vol. 46, p. 385.
[2] William Ernst. *Text Book of Milk Hygiene*, p. 192.
[3] *Journal American Med. Association*, May 1907, p. 1748.

Gastro-Intestinal Disorders, including ordinary Diarrhœa and Dysentery are very common among children fed on cows' or buffaloes' milk. Improper feeding is a frequent cause of diarrhœa in children. Diarrhœal diseases are mentioned as very important factors contributing to infant mortality in India, (*vide* Tables on pp. 109-110).

Infant deaths in Bombay due to Gastro-Intestinal disorders, Diarrhœa and Dysentery vary from 7.15 to 9.33 per cent., giving an average of 8.24 per cent. for the seven years (1907-1913). This represents only the fatal cases of diarrhœa in children under 12 months of age and does not take into account the large number of older children who, as a result of bad feeding, suffer from malnutrition and progressive "debility" and gradually succumb to other diseases, such as Tuberculosis, etc. A great deal of this may be ascribed to the impure milk supply of Bombay. It has been already shown that 93 per cent. of Bombay milk contain B. Coli and other objectionable organisms. The total number of microbes per c.c. is also very large in Bombay milk. From Table IV it will be observed that in Madras the infant mortality from diarrhœal diseases is 27 per cent. of the total—that is more than three times that of Bombay.

In Calcutta, Gastro-Intestinal diseases account for 7.5 per cent. of the total infant mortality. It is difficult to say how much of this is directly attributable to bad milk. Calcutta milk, like Bombay milk, is known to be extremely dirty, yielding total counts from one to three hundred millions of microbes per c.c. and containing bacilli of the colon group in a dilution of 1: 100,000 of a c.c. There can be no question that this is at least partly responsible for the high infant mortality in Indian cities.

Diarrhœa and other Gastro-Intestinal disorders due to bad milk are not confined only to children, but in many instances they can be traced to milk or milk products in the case of adults also. Cases of "ptomaine poisoning" have been ascribed to the ingestion of milk. Vaughan of Michigan, U.S.A., and Firth of Punjab, isolated ptomaines from milk.[1] The symptoms produced are those of severe gastro-intestinal irritation with collapse not unlike those of Cholera.

One of the principal preparations from milk in India which is likely to cause severe gastro-intestinal symptoms[2] is *Mawa.*

[1] *Sanitation in India*, by Dr. J. A Turner, M.D., D.P.H., p. 444.
[2] Ibid, p. 445.

This is practically desiccated milk and is prepared on a large scale in Gujarat by exposing milk in large pans to prolonged low heat. It is used in the preparation of sweets and ices. In April, 1911, there was an outbreak simulating Cholera, in a Mahomedan quarter of Bombay, among certain guests attending a wedding party. It was ascertained that only those who partook of sweets (most of which were prepared from *Mawa*) and of ice-cream suffered severely. Several samples of *Mawa* were examined bacteriologically by the author in this connection. Tests for Cholera Vibrio were negative in all cases, but the majority of samples contained B. Coli communis and allied organisms and streptococci. The presence of such organisms in large numbers in sweetmeats is highly undesirable.

Epidemic Diarrhœa is considered to be an acute infective disease occurring usually during summer months and affecting mainly children under two years of age. Infected milk is the chief cause of this disease. As to any specific organism in the milk, there is still a difference of opinion. B. coli and allied organisms have been usually found to be associated in cases of diarrhœa in infants.

Delepine[1] concludes that epidemic diarrhœa of the common type occurring in England is apparently the result of infection of food by bacilli belonging to the colon group. Savage[2] gives the following figures for the feeding of children under one year of age and its relation to Diarrhœa :—

Method of Feeding.	Healthy Infants.	Infants killed by Diarrhœa.
Cows' milk, entirely or with other food	12 per cent.	42 per cent.
Breast-fed, entirely or partially ..	74 per cent.	10 per cent.

Tuberculosis.—Bovine tuberculosis and its relation to tuberculosis in man, the spread of tubercle bacilli through milk, etc., have been subjects of careful investigation and scientific research in Europe and in America for nearly a decade and a half. Since 1901, when at the British Congress of Tuberculosis, Koch

[1] *Journal of Hygiene*, 1903, Vol. III, p. 68.
[2] W. G. Savage *Milk and the Public Health* 1912, p. 157

made his historic statement,[1] until the present day there have been numerous investigators engaged in the study of this subject; particular mention must be made of the Members of the British Royal Commission on Tuberculosis and the German Tuberculosis Commission, Theobald Smith and others of Washington, D.C., Park, Kruniwiede and others of New York. A brief summary of the conclusions of the British Royal Commission may not be out of place here:—

"There can be no doubt but that in a certain number of cases the tuberculosis occurring in the human subject, especially in children, is the direct result of the introduction into the human body of the bacillus of bovine tuberculosis; and there also can be no doubt that in the majority at least of these cases the bacillus is introduced through cows' milk. Cows' milk containing bovine tubercle bacilli is clearly a cause of tuberculosis and of fatal tuberculosis in man.[2]

"————There can be no doubt that a considerable portion of the tuberculosis affecting children is of bovine origin, more particularly that which affects primarily the abdominal organs and the cervical glands. And further, there can be no doubt that primary abdominal tuberculosis as well as tuberculosis of the cervical glands is commonly due to tuberculous infective material." [3]

The British Commission[4] investigated 108 cases of human tuberculosis and found 19 of them to be of purely bovine origin.

The German Tuberculosis Commission[5] examined fifty-six different cultures of tubercle bacilli isolated from patients suffering from various forms of tuberculosis and found six of them to be of the bovine type.

Lewis, in his study of tubercle bacilli isolated from fifteen cases of tuberculous cervical adenitis, found nine cultures of bovine type and six of human type.[6]

From these and other observations it is evident that a considerable proportion of cases of tuberculosis in man, and particularly in children, are of bovine origin.[7] It has been

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1 Koch announced that human tuberculosis and bovine tuberculosis are two separate and independent diseases, and that tuberculosis of cattle was never conveyed to man as such.

2 Royal Commission on Tuberculosis, Second Interim Report, 1907.

3 *British Medical Journal*, 1903, Vol. I, p. 596.

4 Final Report. 1911.

5 *Tuberculose Arbeiten a. d. Kais Ges. Amt.*, 1904-1905, Heft J.

6 *Transac. 6th Internat. Congress on Tuberculosis*, Washington, D.C., (U.S.A.), Vol. IV, Pt. 2. p. 692.

7 According to Dr. A. Lankester, tuberculosis in man has never been traced in India to tuberculosis in cattle.

further shown that most of such cases in children can be traced to milk infected with tubercle bacilli. Tubercle bacilli have been frequently found in milk in Europe and America.[1] In India, however, they have not been found either in cows' milk or buffaloes' milk. It has been already shown by the author[2] that tubercle bacilli are not known to be conveyed by milk in India and that bovine Tuberculosis is very rare in this country. It is possible, however, to have the milk contaminated through the carelessness of milk-dealers suffering from Pulmonary Tuberculosis, for example, by spitting, sneezing, etc. Samples of sputum were collected from milch cattle stables, milk-shops, dairies and the roadside. 271 such samples were examined for tubercle bacilli by the author and 33 samples, or 12.18 per cent., contained tubercle bacilli. Tubercle bacilli may get into milk in at least four different ways:—(1) *Directly*: from an animal having Tuberculosis of the udder. (2) *Indirectly*: from an animal suffering from Tuberculosis of the lungs. In this case the bacilli may be coughed into the mouth, and being swallowed by the animal would pass on into the fæces and thence find their way into the milk. Cow-dung is used in this country extensively for household purposes and this would be an important agency for the spread of Tuberculosis. (3) The milk from healthy animals may get mixed with milk from Tuberculous animals. (4) (Human) tubercle bacilli may get into the milk in various ways from persons suffering from Tuberculosis. The author has made extensive enquiries of Health Officers and other sanitary authorities in this country regarding any cases of Tuberculosis that could be traced to milk; in every instance the reply has been in the negative. Tuberculosis in India has never been traced directly to milk. The principal reasons for this may be summarised: (1) *The rarity of bovine tuberculosis in India.* This has been already dealt with in Chapter V. (2) *Tuberculosis has never been found in buffaloes in this country*, and it will be remembered that in Indian cities,[3] buffaloes' milk is more extensively used than cows'. (3) *Tubercle bacilli are not known to be conveyed by milk in India.* Several hundred samples of milk obtained from cows as well as buffaloes in Bombay were

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[1] *Vide* page 68.

[2] *Observations on the Bacteriological and Chemical Examination of the Milk Supply of Bombay*, by Dr. Lemuel Lucas Joshi (All-India Sanitary Conference, Lucknow, 1914. Thacker, Spink & Co. Calcutta, 1913).

[3] With the exception of Calcutta.

examined by me with negative results regarding tubercle bacilli. (4) *The almost universal custom of boiling milk* before use in Indian households. (5) *The large proportion of infants in India who are breast-fed.*

In the Table giving various causes of infant mortality in Bombay, Tuberculosis is not mentioned separately, but it is probably included under the column for "Diseases of the Respiratory System," or the one for "Debility," or both. The average under these two headings for the last seven years (1907-1913) is 28.74 per cent. and 30.73 per cent., respectively. How much of this is due to Tuberculosis it is impossible to say. There is, however, some reason to believe that while no authentic case of Tuberculosis in children has been directly traced to milk in this country, the defective feeding of children with contaminated and adulterated milk would tend to lower their general vitality and thus pave the way for the development of Tuberculosis.

Cholera.—The infection of milk may be direct by "carriers," or through infected water added for adulteration. The life of the Cholera Vibrio in milk is rather a limited one. There are at least two cholera outbreaks in India on record which have been ascribed to ingestion of milk infected with Cholera Vibrio. The first outbreak is described by W. J. Simpson,[1] who found several cases of Cholera on board the "Ardenclutha" in the port of Calcutta. Out of the ten men who drank the infected milk four died, five were severely ill, and one slightly ill. The milk was found to be adulterated with 25 per cent. water which was traced to a tank into which cholera dejecta had passed. The second outbreak occurred at the Gaya Jail[2] in July 1894, when twenty-six persons were affected. The milk had become infected by means of flies from cholera stools. It appears that comma bacilli were actually isolated from the milk by Haffkin and Simpson.

Another way in which milk may be infected with Cholera is by means of "carriers.". Major Greig's observations in India go to prove that the "Cholera carrier" is the main source of danger in the propagation of the disease. Recent bacteriological research has brought to light the fact that the human "carrier" is in a position to supply an adequate dose of the virus to various foodstuffs, *e.g.*, milk, and so initiate epidemics of Cholera.

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[1] *Practitioner*, Vol. XXXIV p. 144.
[2] Macrae. *Indian Medical Gazette*, 1894, pp. 407-412.

In addition to patients who are actually suffering from a recognisable attack of the disease, the following may also be responsible for its transmission :—

(1) Those who present a very mild type which is unrecognisable clinically.

(2) Those who are "contacts," *i.e.*, who have been attending on persons suffering from the disease.

(3) Those convalescents who are known as "chronic carriers" inasmuch as they show indefinite periods of latent infectivity and pass cholera bacilli in their stools periodically. It is obvious that the "human carrier" is the most dangerous element in the situation as he is unrecognised and therefore uncontrolled. The handling of milk vessels and the milking of animals by such carriers, specially when their hands are tainted with infected excreta due to carelessness, is a very obvious means by which the milk may receive a very massive infection.

Milk Poisoning or Galactotoxismus.—Under certain circumstances milk may acquire poisonous properties. This subject has been chiefly studied by Vaughan[1] and his associates. Le Blanc,[2] Baird,[3] and others have also contributed to the subject. There are at least five different ways by which poisons may find their way into milk :—

(1) *Milk may absorb metallic poisons from the milk vessels.*—Baird [3] attributed an outbreak of milk poisoning to the preservation of milk in metal vessels. Copper has been found in milk which had stood in contact with copper coil.[4] In India, brass vessels are very commonly used for milk.

(2) *Poisonous substances contained in the food of milch cattle may be eliminated in the milk and cause poisoning.*—In many places certain deleterious weeds are given to the cattle. According to Sonnenberger[5] certain species of clover near Worms (Germany) are found to be poisonous, and when eaten by cows the poisons pass into the milk ; the poisons are not destroyed by boiling the milk. Sonnenberger claims that the feeding of cows with vegetable refuse, *e.g.*, rotten apples, potato tops, etc., tends to poison the milk. According to Rosenau,[6] cows fed upon

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1 Vaughan and Novy. *Cellular Toxines*, Philadelphia and New York, 1902, pp. 211-220.
2 Le Blanc. *Bull. de Lyon Med.*, 1901, p. 586.
3 Baird. *Virg. Med. Semimouth*, 1902-7, pp. 241-242.
4 Golding and Feilmann. *Jour. Soc. Chem. Indus.* 1905, Vol. XXIV, pp. 1285-1286.
5 Sonnenberger. *Verh. d. Gesell f. Kinderheilk-Wiesbaden*, 1896-97. pp. 129-145 ; also *Munich Med. Wochschr.*, 1897, Vol. XIII, pp. 335-338 and Vol. XIV, pp. 363-365.
6 Rosenau. *The Milk Question.* 1913, p. 88.

mouldy grain have been known to cause diarrhœa and vomiting in persons who partake of their milk.

(3) *The elimination in the milk of toxic drugs taken by the mother.*—The excretion of drugs in the milk of nursing women has been exhaustively investigated by Bucura.[1] According to this author only the following drugs have been found with certainty in the milk after their administration to the nursing mother :—iodine, (applied externally or taken internally), salicylic acid and salicylates, ether, mercury, antipyrine, aspirin, arsenic and bromides.

(4) *The production of toxic substances in the milk by the action of bacteria* :—Vaughan in 1884[2] isolated a substance called tyrotoxicon from poisonous cheese in Michigan. Later on, Newton and Wallace,[3] Firth,[4] Vaughan[5] and others found this substance in cases of milk poisoning. Camman[6] reported 23 cases of milk poisoning due to the presence of tyrotoxicon in milk. Vaughan and Novy[7] and others found tyrotoxicon in poisonous ice-cream. The production of different kinds of toxins by various bacteria in milk has been also observed by several workers. Novy[8] found this to be the case with bacteria of the Enteritidis group. Fluegge[9] isolated and studied twelve species of toxicogenic bacteria in milk.

(5) *Milk may acquire poisonous properties as a result of disease in the mother.*—According to Michelazzi,[10] the milk of a tuberculous mother is toxic to the child, and such milk contains a tuberculous poison which is not entirely destroyed by heating at 100°C. Lawrence[11] observed the passage of typhoid bacilli into the milk of a nursing woman who was ill with typhoid fever.

Cases of poisoning due to the ingestion of milk and certain milk products are not uncommon in India. An outbreak in Bombay due to eating "*Mawa*" (which is prepared from milk) has been already described. This may have been due to toxins produced by the bacteria or to the presence of some poisonous substance like tyrotoxicon.

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1 Bucura. *Zeitsch. f. exper. Path. u. Ther*, 1907, Vol. VI, pp. 398 to 414.
2 Vaughan. *Ibid.*
3 Newton and Wallace (*Vide* Vaughan and Novy. *loc. cit.*, p. 215.)
4 Firth. *Ibid*, p. 216.
5 Vaughan. *Ibid.*
6 Camman. *Ibid*, p. 218.
7 Vaughan and Novy. *Ibid*, p. 219.
8 Novy. See *Osler's Modern Medicine*, Phila. & N. Y., 1907, pp. 241-243.
9 Fluegge. See Vaughan, *Twentieth Century Practice of Medicine*, N.Y., 1898, Vol. XIII, pp. 50-52.
10 Quoted by Le Blanc. "*Bull. de Lyon Med.*, 1901.
11 Lawrence. *Boston Med. and Surg. Joun*, Vol. 161 1909, p. 152.

Infant Feeding and Infant Mortality.—Milk is an ideal diet particularly for children, the sick, and the convalescent. It is very important, therefore, that it should be supplied in a pure and fresh condition, free from dirt and disease. It is a well-known fact that in India the mortality among children under one year is extremely high as compared with that in Europe and in America. In 1911 out of 4,752,152 male children and 4,457,550 female children born in India, 1,016,823 males and 873,677 females died. In other words, about one-fifth of the children born in this country die within the first year of their life. This enormous loss of life is of grave concern to the country and is worthy of our most careful investigation. The average of ten years (1904-1913) gives a rate of 217.5 for deaths of children under one year of age to 1,000 births. This is higher than that of any other civilised country, excepting Austria and Russia, as will be observed from the following figures :—

Country.	Deaths under 1 year to 1,000 births—average annual rate during 10 years (1895-1904) unless otherwise stated.	Remarks.
New Zealand	79	
Norway	90	
Sweden	98	Average for 10 years (1894-1903).
South Australia ..	102	
Ireland	103	
Scotland	126	
Denmark	127	
Switzerland	142	
Netherlands	147	
England and Wales ..	150	
Japan	151	Average for 10 years. (1892-1903).
France	153	
Belgium	156	
Ceylon	169	
Italy	170	
Prussia	197	
Hungary	216	
India	217.5	Average for 10 years. (1904-1913).
Austria	224	Average for 8 years. (1895-1902).
Russia (European) ..	268	Average for 10 years. (1892-1901).

Infant mortality in Indian cities is also very high as will be seen from the Tables given below :—

Table I.—Statement showing the rate of Infant Mortality per 1,000 births in some of the principal Indian Cities.

Year.	Bombay.	Delhi.	Calcutta.	Madras.
1904..	459.2	336.4	297.4	280.9
1905..	557.1	340.7	317.1	316.3
1906..	534.7	445.1	340.8	341.2
1907..	423.6	364.8	293.0	270.7
1908..	450.1	500.1	269.6	296.3
1909..	404.7	360.5	268.0	295.0
1910..	413.9	355.0	273.5	294.1
1911..	379.8	418.2	251.6	305.4
1912..	448.2	372.7	259.6	260.4
1913..	381.1	319.9	274.8	293.4
Average for 10 years.	445.24	381.34	284.54	297.3

The *causes of the high infant mortality in Indian cities* are numerous and complex. In general terms, it may be said that *poverty, ignorance and neglect* are the fundamental causes. As a direct result of poverty we have overcrowded districts, insanitary 'chawls," vitiated air, the necessity for mothers to earn their own living—even late in their pregnancy and too soon after confinement (*e.g.*, the mill-hands in Bombay),—insufficient food for nursing mothers and consequently poor milk for their babies, lack of proper rest and recreation, etc. In Bombay, it is not an uncommon practice for working mothers to drug their children with opium as a palliative and economic measure. Ignorance of the simplest facts of the hygiene and physiology of child-bearing and of infant-feeding often lead to disastrous results. The ignorance of the illiterate and meddlesome "midwife" in India is hopelessly profound, and it is a very important cause of the high mortality of children. Neglect of children on the part of Indian mothers is seldom wilful, but is usually the result of poverty or ignorance, or both. It is not proposed to discuss the various causes of infant mortality in India, for that would be outside the scope of our present inquiry; only those factors will be dealt with which have a direct or indirect bearing on the subject of milk and infant-feeding and consequently affecting the health of children through bad milk. It will be seen from the

above that bad milk is only one of the factors which cause such an excessive "slaughter of the innocents" in this country. The main causes of infant mortality in Bombay are Respiratory Diseases, Debility, and Diarrhœa; or in other words, exposure and defective feeding,—both being preventable causes.

A study of Tables II and III will show that in Bombay, "debility" is the largest single causative factor, the average during seven years in Bombay being 30.7 per cent. of the total deaths. By "debility" is understood weakness or feebleness. It is not a separate disease or a pathological entity, but a general symptom. When used in connection with the above Tables, it is believed to include all those fatal cases resulting from lack of general vitality or impairment of strength. *Defective feeding* is a very important cause of debility, and as children under one year are mostly fed on milk, the importance of a pure and clean milk supply becomes quite apparent. Milk adulterated with water is milk of inferior nutritive value and therefore it is not only physiologically unsuitable but tends to produce rickets and a general lowering of the vitality. It is very difficult to show this by means of statistics.

As regards the effects of contaminated milk on the health of infants, a few statistics are available.

Table II.—Principal Causes of Infant Mortality during the first year of life in Bombay.
(1907-1913)

Year.	Small-pox.	Measles.	Gastro-intestinal disorders Dysentery, Diarrhœa.	Diseases of the Nervous System.	Diseases of the Respiratory System.	Debility.	All Other Causes.	All Causes.
1907 ..	19	35	745	1,237	2,516	2,850	874	8,276
1908 ..	236	238	763	1,403	2,557	2,872	1,008	9,077
1909 ..	134	27	611	1,466	2,231	2,626	935	8 030
1910 ..	264	56	674	1,402	2,292	2,567	998	8,253
1911 ..	98	233	581	1,400	2,364	2,364	1,080	8,120
1912 ..	274	82	900	1,570	2,877	2,581	1,362	9,646
1913 ..	55	66	615	1,278	2,113	2,207	1,154	7,488
Average for 7 years..	281.4	105.2	698.4	1,393.7	2,421.4	2,581.0	1,058.7	8,412.8

Table III.—Percentage of Infant Deaths in Bombay from Principal Causes. (1907-1913)

Year.	Small-pox.	Measles.	Gastro-intestinal disorders, Dysentery Diarrhœa.	Diseases of ehe Nervous System.	Diseases of the Respiratory System.	Debility.	All Other Causes.
1907 ..	0.22	0.42	9.0	14.94	30.40	34.43	10.56
1908 ..	2.59	2.62	8.4	15.4	28.1	31.6	11.10
1909 ..	1.66	0.33	7.60	18.26	27.78	32.70	11.64
1910 ..	3.19	0.67	8.16	16.98	27.77	31.10	12.09
1911 ..	1.20	2.86	7.15	17.24	29.11	29.11	13.30
1912 ..	2.84	0.85	9.33	16.27	29.82	26.75	14.12
1913 ..	0.73	0.88	8.21	17.06	28.21	29.47	15.41
Average for 7 years ..	1.77%	1.23%	8.26%	16.59%	28.74%	30.73%	12.60%

Table IV.—Deaths among Infants under one year of age from Principal Causes by age periods in the year 1913 in Madras.[1]

Age-Periods.	Small-pox.	Measles.	Malaria.	Ague and Remittent fever.	Diarrhœa and Dysentery.	Premature birth.	Debility.	Nervous System.	Respiratory System.	All other Causes.	Total.	Percentage of deaths in each age-period to total deaths under 1 year of age.
1 to 7 Days ..	..	..	..	..	43	755	72	502	88	95	1,555	27.22
7 to 30 Days ..	..	5	1	3	153	93	51	461	97	104	968	16.94
1 to 3 Months.	3	..	2	15	194	14	8	202	119	71	628	10.99
3 to 6 Months.	1	4	10	36	361	1	9	223	161	87	893	15.63
6 to 9 Months.	3	12	24	44	416	..	1	117	204	76	897	15.70
9 to 12 Months.	2	9	19	46	384	..	4	69	167	72	772	13.51
Total ..	9	30	56	144	1,551	863	145	1,574	836	505	5,713	....

[1] Administration Report of the Corporation of Madras, Health Department, for 1913, p. 30.

It will be seen from Table IV that in Madras, Diarrhœa and Dysentery account for almost the largest number of deaths among infants : 27 per cent. of the children die from this cause. A study of the Table will show that the incidence of diarrhœal diseases rises continuously until the end of the ninth month, when a slight decrease occurs up to the twelfth month.

According to Dr. Janet E. Lane-Claypon,[1] experimental evidence confirms the conclusion derived from clinical experience as to the superior results obtained by feeding infants or young animals with the breast milk of an animal of the same species, instead of with the milk of another species, and emphasises the opinion that infants should be fed on the breast unless there is an urgent reason to the contrary. In this connection it must be remembered that breast-feeding is much more common in India than artificial feeding. From numerous inquiries made by the Municipal nurses and midwives in Bombay the *percentage of breast-fed children* has been found to be as follows :—

In 1909	1910	1911	1912	1913	1914
64.9	59.8	69.7	66.5	68.4	62.7

No reliable statistics are available in this country regarding the proportion of deaths among breast-fed and bottle-fed infants. From inquiries made in Bombay, it appears, however, that the mortality among artificially-fed children is much higher than that among the breast-fed. In New York, eighty-five per cent. of all infant deaths occur in those that are artificially fed.[2] W. J. Tyson states that of all infants who die in England in the first year of life, seventy-five per cent. have been fed artificially.[3] In Munich the mortality of bottle-fed infants is eighty-five per cent. and that of breast-fed, fifteen per cent. Budin's Chart[4] giving the relative mortality from gastro-intestinal diseases in breast-fed and bottle-fed infants in Paris shows in a very striking manner the advantages of breast feeding and the dangers of artificial feeding. Park and Holt,[5] of New York, carried out an extensive

[1] *Report to the Local Government Board on Public Health and Medical Subjects* (*New Series No.* 63) 1912, by Janet E. Lane-Claypon, M.D., D.Sc., (London.)
[2] Rosenau. *The Milk Question*, pp. 234 and 235.
[3] *Hyg. Laby. Bull, No.* 56. Washington, U.S A., p. 239.
[4] Budin, Pierre. 1905, *Hygiene du Nourrisson*, Paris.
[5] *Archives of Pediatrics*, 1903.

investigation for over two years regarding the different methods of infant feeding. The objects of the investigation were :—(1) To compare the results of the different methods of feeding infants in "tenement houses" in New York (somewhat akin to Bombay "chawls"). (2) To determine how far such results were affected by the character, composition and bacterial content of the milk used. (3) To find out to what extent the results were modified by other factors. These observers studied carefully 632 infants. The different kinds of milk used were briefly as follows :—(1) *Store milk.*—This is sold in the ordinary shops and represents the poorest grade of milk in New York. Bacterial count about 400,000 per c.c. in winter and from 3 to 20 millions per c.c. in summer. (2) *Condensed milk.*—The sweetened variety was used. (3) *Bottled milk.* Two kinds were used, "good" and "best"—the bacterial count was about 500,000 per c.c. (4) *Milk from Central Distributing Stations.*—This was mostly from the Straus Milk Depots. The milk was pasteurised before use. Before pasteurisation, the microbes per c.c. averaged about two millions and after pasteurisation about 500. This was often modified for feeding and supplied in small bottles. (5) *Mothers' milk* (breast feeding). The results obtained by Park and Holt are tabulated below :—

WINTER RESULTS.

Remarks.	Store Milk.	Condensed Milk.	Good Bottled Milk.	Milk from Central distributing Stations,	Best Bottled Milk.	Breast-feeding.
Did Well	47	39	51	35	5	7
,, Fairly.. ..	6	5	13	20	..	1
,, Badly	2	2	1	4	1	..
Died	..	2	3	..	..	1
Total ..	55	48	68	59	6	9

SUMMER RESULTS.

Remarks.	Store Milk.	Condensed Milk,	Good Bottled Milk.	Milk from Central distributing Stations.	Best Bottled Milk.	Breast-feeding.
Did Well	21	22	37	84	9	17
,, Fairly	23	20	23	33	3	7
,, Badly	20	14	29	24	..	7
Died..	15	14	9	4	..	..
Total ..	79	70	98	145	12	31

There is a striking contrast between the summer and the winter figures, the latter showing good results by all the methods of feeding. Park and Holt believe that "there are many factors to explain the differences between the summer and winter results, but that *heat is the primary factor* and bacteria and their products a secondary one, except when the contamination is extreme or pathogenic organisms are present." They lay a special emphasis upon the influence of contaminated milk, and state that with the cleanest milk from the best cared-for cattle the smallest number of bad results occurred.

Park and Holt made further observations on the effects of feeding children with different grades of milk, and the following are some of their conclusions :—

[1](1) The number of bacteria which may accumulate before milk becomes noticeably harmful to the average infant differs with the nature of the bacteria present, the age of the milk and the temperature at which it has been kept. (2) When milk is taken raw the fewer bacteria present the better are the results. Of the usual varieties, over 1,000,000 bacteria per c.c. are certainly deleterious to the average infant. (3) Infants fed on milk previously heated did on the average much better than those who received it raw. (4) A few cases of acute indigestion were seen immediately following the use of pasteurised milk more than 36 hours' old. Samples of such milk were found to contain more than 100 millions of microbes per c. c., mostly spore-bearing varieties. (5) Heat

[1] *Park Wm. H.*, and *Holt. L. Emmett*, "Report upon the results with different kinds of pure and impure milk in infant feeding in tenement houses and institutions of New York City." *Medical News*, Vol. 83, 1903, p. 1066, etc.,

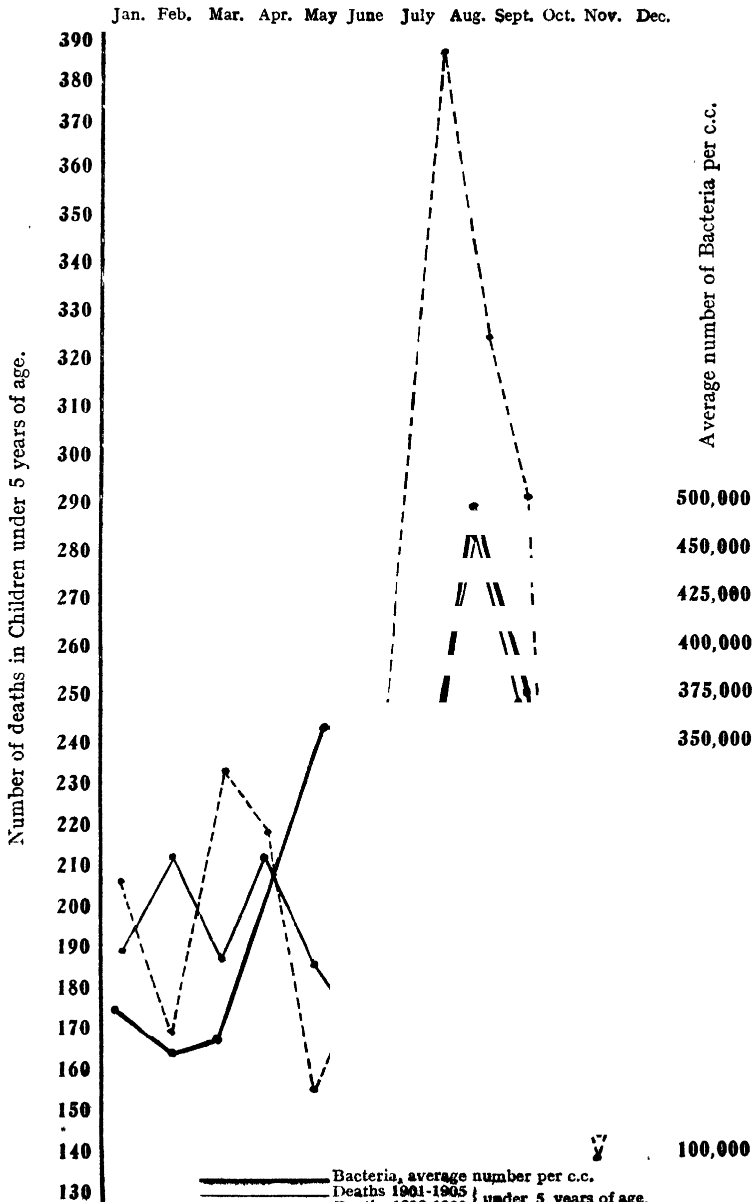
above 170° F. (77°C) not only destroys most of the bacteria present, but apparently some of their poisonous products. (6) After the first twelve months of life, children are less and less affected by the bacteria in milk derived from healthy cattle.

A great deal of valuable work in improving the milk supply has been done by Dr. Goler, Health Officer, Rochester, N.Y., U.S.A. The city of Rochester has a population of 200,000 and the daily supply of milk is 70,000 quarts[1]. Every year bacterial counts of 1,000 samples are made ; fifty per cent. of these (in 1908) yielded less than 100,000 bacteria per c.c. Dr. Goler considers that the reduction which he has effected in the bacterial content of Rochester milk is one of the causes which have brought about a diminution of infantile mortality. The accompanying reproduction of a chart by Dr. Goler[2] is both interesting and instructive. The second chart is from Chicago and shows a comparison between monthly average of bacterial counts and monthly deaths among children from diarrhœal diseases.[3] Both these charts are interesting and suggest a close relationship between the bacterial count and the death rate in children.

[1] *Reports to the Local Government Board on Public Health and Medical Matters* (*New Series* No. 1), 1909, p. 60, by Dr. Arthur Eastwood.
[2] *Archives of Pediatrics*, September 1906.
[3] Rosenau. *The Milk Question*, p. 217.

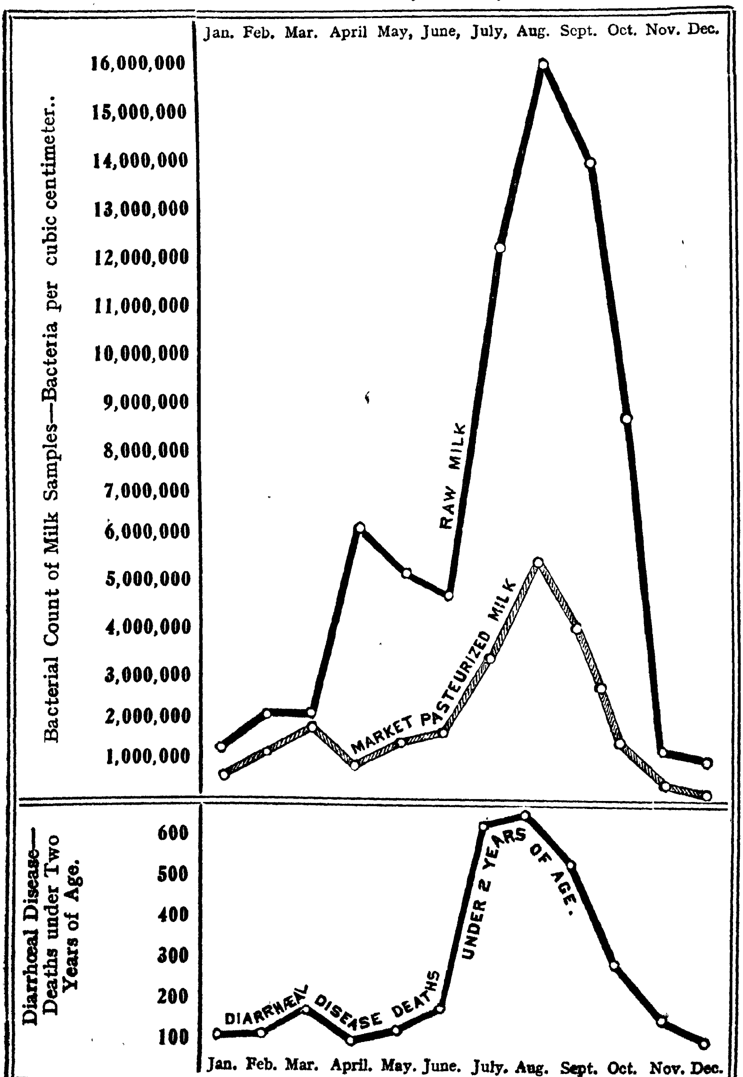
[DIAGRAM PLATE.

AVERAGE NUMBER OF BACTERIA IN MILK: Deaths under 5 years.



BACTERIA FOUND IN RAW AND PASTEURISED MILK.

Monthly average of Bacterial Counts, 1910, *compared with monthly deaths among children from Diarrhœal Diseases.* (*From Chicago Commissioner of Health.*)



There is no doubt that child mortality has decreased considerably in many cities abroad since the use of pasteurised milk for children. Nathan Straus introduced pasteurised milk in New York in 1893, when 34,400 bottles of milk were dispensed from one depot. The work gradually increased until in 1906, 3,142,252 bottles and 1,078,405 glasses of pasteurised milk were dispensed from 17 "Straus Milk Depots." Prior to 1893 the death rate of children under five years of age in New York was over 96.2 per thousand and in summer (June, July, and August) this rate was 136.4 per thousand per year. With the increased use of pasteurised milk the death rate was reduced to 55 per thousand in 1906 and the summer death rate to 62.7 per thousand per year.

Besides pasteurisation, there are two other methods of artificially purifying milk—namely, *boiling* and *sterilisation;* as the practice of boiling milk is followed in nearly every Indian household, it would be important to study the effects of boiled milk on health—particularly with regard to children. A very exhaustive report[1] to the Local Government Board was made in 1912 by Dr. Lane-Claypon "upon the available data in regard to the value of boiled milk as a food for infants and young animals." The report includes both experimental and clinical observations of different workers. It does not deal with the digestibility of raw and boiled milk, but is concerned with the study of the *comparative nutritive value of raw and boiled milk*: (1) *of the same species, and* (2) *of a foreign species.* The clinical material provided for was a large number of healthy babies under medical supervision, and of known, and so far as possible, the same social environment, who were fed for a prolonged period upon raw and boiled cows' milk. Further, a "control" was used—of babies drawn from the same average population fed in different ways. The material selected for the investigation was from the Infant Consultation in Berlin—under Prof. Finkelstein and Dr. Ballin. The infants were weighed from time to time and the weights noted. Numerous experiments on animals were also performed. Dr. Lane-Claypon draws the following *summary* and *conclusions* in the report :—

"The balance of evidence both experimental and clinical points in the main to the same conclusions. Both lines of research show :—

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[1] *Reports to the Local Government Board on Public Health and Medical Subjects (New Series No. 63)*, by Janet E. Lane-Claypon, M.D., D.Sc., 1912.

"(1) That there is apparently no serious loss of nutritive value produced by feeding an animal upon boiled milk derived from an animal of the same species. At the same time it must be pointed out that the published evidence on this point is scanty.

"(2) That when an animal is fed upon the milk of another species, the milk from which has been found to be suitable for this purpose, such small differences as have been found in the nutritive values of raw and boiled milk have been in favour of boiled milk.

"(3) That the milk of the same species has a considerably higher nutritive value for that species than the milk of any other species so far investigated.

"The evidence dealt with throughout this report emphasises very forcibly the *importance of breast-feeding* for the young of all species and shows the special importance of breast-feeding during the early weeks of life."

Milk is deprived of its enzymes or ferments by boiling, and this has been often brought up as an objection to the use of boiled milk. As will be shown under the "Biological Properties of Milk" this objection is more theoretical than practical—for no one has yet definitely proved the biological value of these enzymes in milk. So far as our present knowledge goes, it may be concluded that *boiled milk is not inferior to raw milk as regards its digestibility and nutritive properties.*

Sterilisation of milk is a step further than boiling. This brings about more profound changes in the character and composition of milk than boiling (*vide* Chapter V). As in the case of boiled milk, there is considerable amount of evidence to show that sterilisation of milk does not seem to interfere with its nutritive qualities. The observations of Variot and other French observers are worth recording. Variot[1] sums up his experiences as follows :—

"At the dispensary of La Goutte de Lait de Belleville, which I have directed since 1892, we have distributed for twelve years in the poorest quarters of Paris about four hundred thousand bottles of sterilised milk to more than three thousand infants of the working class deprived of their mothers' milk. With my collaborateurs, MM. Drs. Dufestel, Lazard, and Roger, we have made a study of the artificial feeding with sterilized milk, and the results of our experiments are so decisive, each case controlled by weight, and an examination of the organs and functions, that we think our results merit publication.

[1] Variot, M. G. "Valeur nutritive du lait de vaché stérilise à 108° pour l' allaitement artificiel." *Comp. rend. des seances de l'Acad. d, Sci.* Vol. 139, 1904, p. 1002, (from Rosenau.)

The milk received from farmers in the country is heated to 108°C. before transportation in the bottles of half a litre, stoppered with cork and the medical seal. This milk keeps several days without alteration, even during the greatest heat of summer. It is delivered daily at the Belleville dispensary to one hundred and fifty infants. Every week, or oftener if necessary, the infants are weighed and inspected with care, records of which are kept. The following are some of the conclusions of the results of twelve years' experience :—

1. The milk sterilised at 108° C. preserves all of its nutritive value. It is not inferior to milk pasteurised at 80° C. or with heating at 100°C. in the apparatus of Soxhlet.

2. The destruction by heating of the enzymes, the slight alteration of the lactose, the doubtful precipitation of the citrate of calcium, or the alteration of the lecithins does not affect its assimilability in an appreciable manner. Not one case of infantile scurvy has been observed by the dispensary.

3. Thanks to this sterilised milk we have been able to raise not only healthy infants, but also atrophic infants, retarded in their development as the result of gastro-intestinal troubles.

4. Rachitis did not develop in any of the infants.

5. In three thousand infants of the poorest class about three or four per cent. showed themselves incapable of using sterilised milk,

6. Constipation and anæmia were not rare among the infants raised by this method. On the other hand the summer diarrhœa were markedly attenuated in severity."

Maygrier[1] states that of 590 infants fed on sterilised milk, not one died of Diarrhœa.

Berlioz[2] reports that it is possible to reduce infant mortality by the use of sterilised milk. He sterilised milk at 110°C for half an hour before distributing it in bottles. The following death rates were observed :—

Year.	Class A. Children fed on milk not sterilised (per 1000).	Class B. Children fed on sterilised milk (per 1000.)
1894	66.8	25.6
1895	86.9	42.2
1896	54.0	16.1
Average	69.3	27.9

[1] Maygrier. "La Consultation de nourrisson à la Charité, de 1898 à 1901, *Obstetrique*, Vol. 6, 1901.
[2] Rosenau. *The Milk Question*, p. 220.

The difference in favour of sterilised milk is much more striking than the figures indicate, for Class A includes bottle and breast-fed children, while Class B includes only bottle-fed children. Further, the first figures are compiled from children of the better class while the latter are drawn from children of the poorer classes.

The above-mentioned facts are all in favour of the use of heated milk. On the other hand, there are a few observers who claim that the prolonged use of heated milk leads to scurvy and rickets in children.

According to Ernst,[1] children who are exclusively nourished on sterilised milk become affected with infantile scorbutus or " Möller-Barlow disease," which disappears when raw milk is provided. He does not quote any statistics, however, in support of this view.

Rummell[2] doubts the relationship between the Möller-Barlow disease and sterilised milk. The cause of the disease is entirely unknown, and perhaps it has some relation to the food of the cow rather than to the heating of the milk. Escherich says: " Infantile scurvy I have not once seen among all the many thousands of children fed artificially and with sterilised milk which passed through my hands in München and Gray."[3]

Koeppen[4] considers scurvy as an auto-intoxication brought about by intestinal putrefaction.

According to Rosenau[5] " scurvy may be brought about by the lack of inorganic salts of alkaline bases, especially potassium, in the infant's dietary. This, combined with the injurious effects of a high percentage of fat in the food, may bring about serious disturbances of digestion and metabolism favouring the production of the scorbutic condition." The last is a very recent view on the matter, and if it is correct, then the use of heated milk could not be an etiological factor in scurvy in children.

Here, in India, where boiled milk is most commonly used for children, infantile scorbutus or Möller-Barlow's disease does not seem to be very prevalent. The disease is rare in Germany and France where feeding with heated milk is very popular.

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1 Wm. Ernst. *Text Book of Milk Hygiene*, p. 194.
2 Rummel, O, " Sterilisierte Milch ? " *Deut. Praxis.* Vol. XIII, pp. 201-207.
3 Escherich *Wiener klin Wochens*, Vol. XIII 1900, p. 1,
4 Kœppen, " Zur Moller-Barlow schen Krankheit," *Jahrb f. Kinderheilk.. Bd.* 44, 1897.
5 Rosenau, *The Milk Question*.

The comparative advantages and disadvantages of pasteurisation, boiling and sterilisation will be considered in the next chapter.

The Use of Preservatives in Milk.—Chemical preservatives are added to milk in order to prevent or retard the growth of bacteria, and thus preserve or keep the milk for a considerable length of time by delaying the lactic-acid fermentation. The preservatives used most frequently are formaldehyde and boric acid or its compounds. Among other preservatives employed occasionally are salicylic acid, benzoic acid, hydrogen peroxide, sodium carbonate, certain fluorides, potassium dichromate, etc.

The amount of different preservatives necessary for *keeping* the milk for various lengths of time has been studied by several workers. The following table is from Richmond[1] :—

Table of the Length of Time in Hours that Milk will keep at various Temperatures when Preservatives are added:—

Temperature.	Boric Acid.		Formaldehyde.		
	0.05 Per cent.	0.10 Per cent.	0.0025 Per cent.	0.005 Per cent.	0.010 Per cent.
60°F. ..	26 hours.	40 hours.	8 hours.	35 hours.	63 hours.
70°F.	6 ,,	14 ,,	5 ,,	17 ,,	41 ,,
80°F.	3 ,,	9 ,,	4 ,,	13 ,,	31 ,,
90°F.	2 ,,	8 ,,	2 ,,	11 ,,	26 ,,

According to Richmond, for prolonging the "life" of the milk by 12 hours at 80° to 90°F at least 0.09 per cent. of boric acid or 0.004 per cent. of formaldehyde are necessary. As regards the possibility of any injurious effects resulting from the use of preservatives, different observers are divided in their opinion. Rideal and Foulerton,[2] for instance, conclude from their work that boric acid, 1:2,000, and formaldehyde, 1:50,000, act as efficient preservatives for milk for 24 hours, and that in these quantities they have no appreciable effect on digestion or on the digestibility of foods thus preserved. On

[1] H. Droop Richmond, *Dairy Chemistry*. Second edition, 1914, p. 178.
[2] Rideal and Foulerton. *Exp. Stat. Rec.* 1900, 11, 582 from *Public Health*, 1899. 11-554-568; see also *Lancet*, 1900, pp. 228-230.

the other hand, Halliburton[1] observed that 0.5 per cent. of formaldehyde renders gastric digestion almost impossible, and 0.05 per cent., delays it considerably; while according to F. J. Allan (quoted by Halliburton[1]) borax delays or prevents the rennin coagulation of milk. Halliburton in his testimony before the Food-Preservatives Committee in London took his stand against the use of preservatives in food. A great deal of work was done by Liebreich[2] on the effect of boric acid and borax on the human system. He is of opinion that experience justifies the use of boric acid and borax as food preservatives.

Numerous other investigators have tested the effects of preservatives on digestion, metabolism, etc., but space will not permit these investigations being discussed in detail. *The consensus of opinion is against the use of preservatives in milk.* Savage[3] sums up the essential objections to the addition of any preservatives to milk as follows:—

(1) There is evidence that their consumption may be directly harmful.

(2) The action of preservatives upon bacteria is not a simple general one, but is selective.

(3) Their addition is totally unnecessary and is a direct incentive to dirty methods of milking and handling milk. Their use converts a perishable article into a comparatively non-perishable one and allows surplus milk to be kept over until next day.

The following recommendations were made by the Departmental Committee, London:—

(A) That the use of formaldehyde or formalin, or preparations thereof, in foods or drinks be absolutely prohibited.

(B) That the use of any preservative or colouring matter whatever in milk offered for sale in the United Kingdom be constituted an offence under the Sale of Food and Drugs Act.

(C) That the only preservative which it shall be lawful to use in cream be boric acid or mixture of boric acid and borax, and in amount not exceeding 0.25 per cent. expressed as boric acid. The amount of such preservative to be notified by a label upon the vessel.

[1] Halliburton, *Brit. Med. Jour.*, 1900, Vol. II, pp. 1-2.
[2] *Liebreich. Second Treatise on the effects of Borax and Boric acid on the Human System*, by Dr Oscar Liebreich, London, 1902.
[3] *Milk and the Public Health*, by William G. Savage, 1912, p. 389.

Several samples of milk imported from distant places, *e.g.*, Gujarat, were examined by me for the presence of preservatives. It was found that almost all the samples contained formaldehyde, excepting those samples which were subjected previously to pasteurisation and cooling. Statistics from other Indian cities, with regard to the addition of preservatives to milk, are not available.

THE " BIOLOGICAL " PROPERTIES OF MILK.

It has been shown above that infants fed on *raw mothers'* milk thrive on the whole better than those receiving *boiled cows'* milk. Escherich[1] in 1900 suggested that the difference might be due to " metabolism-ferments " (*stoffwechsel fermente*). Later on it was found that raw milk possessed the property of giving certain colour reactions, which property was lost by heating the milk to a definite temperature. Numerous observers have investigated this subject and have found various kinds of *enzymes* or *ferments* in raw milk.

Besides enzymes, other " biological substances " have been found in milk, *e.g.*, precipitins, agglutinins, etc. The discovery of these was based on the observations of Ehrlich and others, who showed long ago[2] (1892) that passive immunity could be produced by suckling when the mother was immune. These bodies (agglutinins, anti-bodies) are called " protective substances " and are responsible for the so-called " germicidal property " of milk.

The " biological " properties of milk are due to the presence of two kinds of substances in milk which are different from *chemical* substances (*e.g.*, sugar , fat, etc.) and which are termed " biological " substances, namely, (I) *Enzymes* or *Ferments*, and (II) *Protective Substances* or *Immune Bodies*.

(I) **Enzymes or Ferments in milk.**—Under this term are included those substances which hasten chemical changes with extreme rapidity without using themselves to an appreciable degree. Their activity is inhibited (1) by the products of the reaction, (2) by high degree of heat, and (3) by certain ferment toxins, *e.g.*, hydrocyanic acid. Their mode of action is by (1) oxidation, (2) reduction, or (3) hydrolytic splitting.

[1] Escherich's article in " Wiener Klin Wochens," 1900, Vol. XII, p. 1184.
[2] Ehrlich, *Uber Immunitat durch Vererbung und Saugung. Zeit f. Hyg.* 1892, Vol. XII, P. 183.

The ferments, or groups of ferments, described as occurring in milk are (1) Amylase, (2) Catalase, (3) Oxidising ferments, (4) Reducing ferments, (5) Proteolytic ferments, (6) Lipolytic ferments, and (7) Glycolytic ferments. These are minutely described by Dr. Janet E. Lane-Claypon of London in an excellent report to the Local Government Board on the "Biological Properties" of milk.[1] It is not proposed to discuss all these enzymes here; we can only briefly refer to the important ones and find out if they have any practical significance.

According to Ernst[2] the important ferments in milk are *amylase* (*diastase*), the *indirect oxydase* (*peroxydase*), the *superoxydase* (*catalase*), and the *indirect reductase* (*aldehydreductase*). Their diminished or increased presence or complete absence offers certain conclusions as to various conditions in the udder or in the milk.

Amylase (*diastase*) splits up the starches, its action being similar to the ptyalin of the saliva. This enzyme is present in human milk and in cows' milk. It has also been *found in buffaloes' milk in Bombay* by the author. Amylase is destroyed by heating at 68° C for 45 minutes (Koning).[3] According to Giffhorn[4] 100 gms. of milk will decompose from .01 to .25 gms. of starch. The amount of amylase is *increased in pathological conditions of the udder.*

The indirect oxydase or peroxydase acts only after the addition of hydrogen peroxide. According to Lane-Claypon, it is constantly present in cows' milk, but is very inconstant in its appearance in human milk. Its *presence has been demonstrated by the author in buffaloes' milk in Bombay* (using *Storch's* reaction and the guiac test.) The reaction is more marked in colostrum and in milk in Mastitis. The ferment is probably derived from broken-down cell-tissue and from the leucocytes. It is difficult to state the precise temperature at which the peroxidase reaction ceases to be given, as different observers give different temperatures, varying from 70° C to 82° C. The ferment is destroyed by heating at about 75° C for 5 minutes (Seligmann), for 10 minutes (Rullmann), or for 20 minutes (Kastle and Porch).

Catalase or Superoxydase.—This enzyme originates in the cells of the milk gland, especially from the leucocytes (Ernst). It

[1] New Series, No. 76-1913.
[2] William Ernst. *Text Book of Milk Hygiene*, 1914, p. 46.
[3] Quoted by Ernst in his *Text Book of Milk Hygiene.*
[4] (Quoted by Lane-Claypon) Giffhorn. "Untersuchungen uber Enzyme in der Kuhmilch" *Inaug. Dissert.* Hannover 1909.

has been found in the milk of all animals. It has the property of splitting hydrogen peroxide according to the equation $2H_2O_2 = 2H_2O + 2O$. The literature dealing with this enzyme in milk is very voluminous. Heating to 62 to 70° C destroys the original catalase in a short time. Different kinds of apparatus have been devised for measuring accurately the amount of oxygen evolved during a definite period of time. A description of these will be found in Lane-Claypon's report.[1]

The amount of catalase in several samples of buffaloes' milk in Bombay was determined by me with the aid of a simple apparatus consisting mainly of a graduated burette. Fifteen c.c. of milk and 5 c.c. of H_2O_2 (one per cent.) were used and the amount of oxygen evolved in one minute, 5 minutes, 15 minutes and 30 minutes was recorded. In the beginning, observations were taken for ¾ hour, 1 hour, 2 hours, and 3 hours, but as it was found that the amount of oxygen evolved practically reached its maximum within half-an hour, there being hardly any appreciable increase in 1 hour or more, the time limit was fixed at 30 minutes. Several samples of milk were thus examined for catalase and the amount of oxygen evolved was noted. It was found that in fresh samples of milk, the amount of oxygen evolved varied from 1.5 c.c., to 2.5 c.c,. while in market milk (examined usually from 8 to 9 hours after milking) the average amount of oxygen in fifty samples was found to be 4.5 c.c. This indicates that freshly obtained milk shows less catalase than milk which has been standing for 8 to 10 hours, particularly when it is contaminated.

Many of the samples were analysed chemically and it was found that *the amount of catalase usually varies directly with the percentage of fat in the same sample of milk,* the higher the fat the greater the amount of catalase, provided that the interval of time between milking and examining the sample is approximately constant.

[1] See footnote 1 on page 124.

[TABLE.

The following samples illustrate this point :-

No.	Time in Minutes. 1	5	15	30	Fat Percent.	Remarks.
	Amount of oxygen evolved in c.c.					
1..	0.5	3.2	6.1	7.4	7.7	The time elapsing between milking and taking observations varied from six to eight hours approximately. This accounts for the high figures for catalase.
2..	1.0	3.0	6.0	7.6	7.5	
3..	0.2	0.5	1.7	2.7	4.2	
4..	0.1	2.1	4.0	5.1	6.0	
5..	0.1	1.4	3.8	5.7	6.6	
6..	0.1	1.8	4.0	5.1	4.9	
7..	0.4	2.5	5.1	6.0	5.1	
8..	0.1	0.9	3.6	4.7	5.8	
9..	0.2	2.1	4.8	6.4	7.0	
10..	1.0	5.0	8.2	9.7	9.5	
11..	0.4	1.5	4.6	6.6	7.0	
12..	0.1	0.7	2.1	3.0	4.0	

These results have been further confirmed by examining the milk for catalase before and after removing the cream.

According to Lane-Claypon: "There appears to be a special affinity between the catalase and the fat content of the milk, since if the milk be centrifuged the major part of the catalase goes up with the cream." She quotes the following figures from Seligmann :—

25 c.c. skim milk gave 1.2 c.c. O_2 with 0.5 c.c. perhydrol in 1 hour at 37°C
,, ,, Whole ,, ,, 4.0 ,, ,, ,, ,, ,, ,,
,, ,, Cream ,, ,, 7.3 ,, ,, ,, ,, ,, ,,
Watery extract
from cream. ,, 12.0 ,, ,, ,, ,, ,, ,,

According to Gerber and Ottiker[1] the catalase content of the milk varies with the breed of the cow, the feeding and other factors. Spindlers[2] and others found an increase of catalase (in freshly obtained milk) in all inflammatory conditions of the udder. Milk rich in cellular elements also contains a large amount of catalase. Jensen observed[3] that the bacterial flora present in milk during the incubation period of souring usually possess strong catalytic properties.

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[1] Gerber and Ottiker. "Zur Katalase Bestimmung der Milch," *Milchw Zentralb.* 1910, Vol. VI, p. 316.
[2] Spindlers. "Beitrage zur kenntniss der Milchkatalase." *Bioch. Zeit.* Vol. XXX, 1911, p. 384.
[3] Wm. Ernst. *Text Book of Milk Hygiene*, p. 187.

Catalase is known to be destroyed at a temperature of about 70°C. The catalase test, therefore, may be applied to pasteurised milk to find out the efficiency of pasteurisation, as well as any subsequent contamination. This is a simple and rapid routine test and would be of great value in determining the suitability of a sample of milk for drinking purposes.

As regards any relationship between the bacterial count and the catalase, most observers are of opinion that although the catalase content is increased by bacterial contamination, there is no definite relationship between the number of microbes and the catalase content of the milk. Catalase has been found in human milk and it appears that the healthier the woman, as a whole, the less the catalase.

Indirect reductase (*aldehydreductase, etc.*), or "*Schardinger's ferment,*"—Schardinger[1] found that fresh milk possessed the property of reducing methylene blue in the presence of formalin. The reaction is known as "Schardinger's Reaction." A great deal of controversy has been raging between different observers with regard to the origin and nature of this "ferment" (*vide* Lane-Claypon). *Indirect reductase* has been found to be *present in cows' milk as well as in buffaloes' milk* by the author, but is *absent in human milk.*

The practical significance of enzymes in milk may be now considered in the form of two questions :—(1) *Would the presence* (increased or diminished) or *the absence of any enzyme in milk serve as an index or guide to the quality or character of the milk or to the various morbid conditions of the milch cattle?* and (2) *Have the enzymes in milk any "biological value" in relation to the feeding of infants?* The first question has been already answered above. It was shown that amylase, peroxidase, and catalase are all increased in Mastitis and other conditions of the udder, that catalase usually bears a definite ratio to the fat content of the milk and that the amount of catalase is increased by bacterial contamination. As catalase is found in all tissue extracts, its absence in milk, rather than its presence, would be cause for inquiry (Lane-Claypon). As regards the second question, it has often been asserted that enzymes in milk are concerned in digestion and their presence in milk is essential for the proper nutrition, etc. of children. This assertion does not seem to be

[1] Schardinger. *Zeit. f. Unters. Nahr. u Genussm.* 1902, Vol. V, p. 1113 (quoted by Lane-Claypon.)

based upon any reliable clinical evidence or scientific experiments. The comparative merits of feeding infants on breast milk, raw and heated cows' milk have been already fully discussed. It was stated that while *breast milk is undoubtedly the most satisfactory and best feeding for infants,* both clinical and experimental evidence show that the *nutritional value of boiled cows' milk is not,* on the whole, *inferior to that of raw cows' milk.* If the enzymes in milk had any biological value, the results of feeding with boiled milk should have been unfavourable (for boiling kills all the enzymes); but such is not the case.

If we consider the above-described enzymes individually, none of them seem to have any biological significance with regard to infant feeding. *Peroxidase,* for instance, is destroyed by acid and by the gastric juice, so that its life as an enzyme must end on reaching the stomach; moreover, the irregularity of its appearance in human milk would also constitute as an argument against attaching any biological value to this enzyme. The *indirect reductase* is *entirely absent in human milk* and hence its presence could not be essential to digestion, etc. *Amylase* is a starch-splitting enzyme; starch is considered to be an unsuitable food for infants, and as starch is not a constituent of milk, amylase would be unnecessary for the purpose. If they have no biological function then how is the presence of enzymes in milk to be explained? Lane-Claypon suggests that "peroxidase, catalase, and amylase are found in considerable amounts in the blood, and it is only consonant with general physiological experience to suppose that the small and varying amounts of these ferments which are found in milk are derived from the blood stream by filtration." As to their biological significance, she adds that: "as a result of the survey of the available data upon the ferments present both in human and in cows' milk, *there appears to be no ground for claiming any biological value for these substances.*" The answer to our second query would be therefore in the negative.

II "Protective Substances" or Immune Bodies in Milk.—By "protective substances" are understood certain bodies found in the blood which afford protection or immunity to the organism from certain diseases. Five classes of such substances have been described in milk:—

1. Precipitins, those bringing about the precipitation of certain substances.

2. Agglutinins, those bringing about agglutination of bacteria.

3. Anti-toxins.

4. Bodies concerned in the "germicidal properties" of milk.

5. Those concerned with hœmolytic action.

The consideration of milk as an *Antigen* and carrier of anti-bodies would be of great scientific interest, for that would possibly provide a means of differentiating between cows' milk and buffaloes' milk. No attempt will be made here, however, to deal even briefly with the general question of "protective substances" in milk. Mention will only be made of any possible bearing of this subject on the feeding of infants.

No original work has been carried out by the author as yet with regard to this subject and he can therefore only refer to a summary (by Lane-Claypon) of our present state of knowledge based mainly upon German and American investigations. Lane-Claypon summarises the results regarding the presence of "protective substances" in milk as follows :—

"1. Colostrum contains substances (*a*) acting hœmolytically upon certain blood corpuscles, and (*b*) inhibiting the growth of bacteria, whether through bacteriolysis or agglutination.

"2. Later milk may contain traces of these substances, but if present at all they are present in very small amounts.

"3. The apparent bacteriolytic effect possessed by raw milk seems to be due to its agglutinating powers ; this power is lost in the early hours after milking.

"4. If specified immune substances are present in the blood of the mother, they pass out in the milk but are present in smaller amounts than in the blood."

With regard to their absorption, the following conclusions are drawn :—

"1. Absorption of protein and hence of the attached immune substances takes place directly during the first few days after birth.

"2. Foreign protein is not absorbed as such, except in the early days after birth.

"3. It is possible that native protein may be absorbed directly for a longer period.

"4. Protein can apparently be absorbed at a later age in significant quantities in cases of disturbance of the alimentary canal, or of presence of excess of protein."

As regards cows' milk, it has been found that *the "biological substances" are not absorbed in the alimentary canal but are destroyed there.* Judging from the investigations quoted by Lane-Claypon, *the "biological substances" in milk do not appear to have any direct value.*

It may be mentioned, in conclusion, that a substance called "*Vitamine*" has been isolated from vegetable tissues and also from milk by Funk. It appears that *Beri-beri* (a disease which appears to belong to the "Scurvy" group) can be cured by the administration of "Vitamine." It has been suggested that infantile scurvy may be caused by the deficiency of this substance in milk. At present, however, the available data regarding this is very scanty and indefinite.

CHAPTER VII.

REMEDIAL MEASURES.

In the foregoing pages an attempt has been made to present the milk problem in Bombay and other Indian cities in its many phases and from various points of view. It is apparent that the milk problem in this country is much more complex than in Europe or in America. The remedial measures suggested in this chapter are by no means complete or perfect. Only a brief description of the important measures will be given here. For the sake of convenience, the remedial measures will be discussed under the following headings :—

I. *Economic, educational and other general measures*, including improvement of the Indian milch cattle, reforms in the production and distribution of milk, education of the milk dealers, co-operative dairy societies, etc.

II. *Sanitary measures*, including sanitary methods and reforms regarding the care and management of the milch cattle, the process of milking, the storage, transit, distribution and the artificial preservation and purification of milk.

III. *Legislative control*, including milk inspection and legal milk standards.

I. ECONOMIC, EDUCATIONAL AND OTHER GENERAL MEASURES.

(A) **Improvement of the Milch Cattle,** with regard to (*a*) *breed*, (*b*) *feeding*, (*c*) *housing and tending, etc.*

(*a*) **Breed.**—The question of breed and heredity has been already discussed in Chapter II (*q.v.*). The Indian breeds as a whole give a much smaller amount of milk than the European or American breeds. Our aim should be to so improve the animals as to enable them to increase their yield of milk. From the Tables on pages 39-40 it will be seen that there are great variations even among the existing breeds. The largest amount of milk is given by the *Delhi* and *Jaffrabadi* buffaloes and the *Saniwahl, Hansi, and Sindhi* cows. Half-bred animals from Sindhi cows and imported Ayrshire bulls also yield the largest amount of milk.

It has been pointed out that in the same breed there are great differences in the composition of milk of each *individual* animal. The improvement of the existing breeds is a question of many years. A beginning could be made by training the cattle-owners

in the art and science of breeding and of selection. Most of the cows in India are not primarily produced for milking purposes but are more or less incidental in the course of breeding of draught animals. Cows and bullocks are needed in this country only for two purposes, namely, *milking and draughting.* Beef is hardly used here as food and so there is no necessity of breeding cows for that purpose as in Europe or in America. The bullock is *the* animal used here for ploughing and draughting purposes. *The aim of breeding should be the production of a class of animal, the female of which would be our best milker, whilst the male would be our most efficient draught animal.* According to William Smith,[1] the main characteristics of a first-class milch cow are, that she "must be gentle, maternal, fairly fine bone, not too long in the leg, and of massive frame with well-knit symmetrical figure. She must possess great digestive and assimilative ability and have special room for large healthy internal organs; in other words, you want size without height, weight without excessive flesh, frame rather than beef, breeding (which means spirit) rather than bulk, placidity of temper rather than showiness, and the wedge-shape in preference to the elephantine type." He then adds: "Surely all these are characteristics of a first-class plough or draught bullock as well as of a first-class milch cow." What is really required for this country is "a thick set animal with clean legs," mildness of temper, quick action, roomy barrel and average height.

The bulls for breeding purposes must be selected very carefully from a pure breed of known milking qualities. Only such bulls should be chosen whose immediate ancestors, and particularly the mothers and sisters, were or are known to be good milkers. It is not advisable to import expensive European stock for the purpose of producing the "dual purpose cow" for India. The half-bred progeny is usually delicate and very susceptible to disease. The cows give more milk but the quality of the milk is poor in fat as compared with the pure Indian breeds.

Satisfactory results are reported to have been obtained in the Punjab and Sindh in an attempt to breed a "dual purpose animal." In the opinion of the Committee at the Agricultural Conference at Coimbatore (December, 1913) it is possible to breed the above type of animal in India. According to the investigations of William Smith, the best milkers in almost every case

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[1] *The Journal of Dairying and Dairy-Farming in India,* Vol. I, Part 2, p. 88.

produce the best bullocks. The same principle may be applied to buffaloes also. Among the best breeds of cows may be mentioned the Saniwahl, Hansi, Sindhi, and Gir, and among the best breeds of buffaloes are the Delhi, Surati, and Jaffrabadi. He-buffaloes could be trained for draughting and ploughing purposes like bullocks. Select he-buffaloes for breeding purposes should be also kept in the same manner as bulls.

The influence of *climatic conditions* is important for satisfactory breeding in India. According to Mollison,[1] the finest cattle in India are bred in districts where there is a decided degree of cold during the winter. In the Bombay Presidency the best cattle are bred in Northern Gujarat, which possesses extensive tracts of good grassland with fairly abundant pasturage all the year round. The Gir hills in Kathiawar and the Satpuras offer the most favourable natural conditions for the breeding of cattle in the Bombay Presidency. The land being uphill is well drained and has an ample water-supply. The soil is of fair depth and quality, and the subsoil fairly pervious to rain. The annual rainfall in these districts rarely exceeds 35 inches. On the other hand, in the Deccan, natural conditions are, on the whole, unfavourable for breeding purposes. Most of the districts are subject to deficient rainfall, scarcity of fodder and occasional famines. In the Konkan also, that is below the Ghauts, the climatic conditions are unfavourable; the rainfall is too heavy for successful breeding, and the soil is reported to be unsuitable for raising proper fodder crops.

It is evident from the above that the breeding of the "dual purpose" animal should be undertaken by the well-to-do cultivator in India. With reference to this subject, Professor Knight and Mr. Horne of Poona say,[2] "The development of a profitable dairy animal from any of the types mentioned above, without outside blood, is the work of generations, working on scientific principles, consistently, intelligently, and persistently. The agency for effecting this is difficult to point out. The necessity for continuity in this work is so great that it places it beyond the scope of Government Institutions, because of the necessary frequent changes of personality. The only agency which could undertake this work with a reasonable expectation of accomplishing marked results does not evince any great interest in

[1] *A Text-Book on Indian Agriculture*, by J. Mollison, M.R.A.C., Vol. II, 1901, p. 2.

[2] J. B. Knight and E. W. Horne, *Dept. of Agriculture, Bulletin No.* 56 *of* 1913. "Present state of the Dairying Industry in Bombay."

work of this character. We refer to the hereditary Chiefs and Sardars, who have estates adapted to the work, and who, if they were really in earnest, could carry on this work from father to son, along fixed lines and accomplish something. If the above-noted gentlemen could be aroused to form Breeders' Associations and definite ideals laid down, and authentic records of breeding and production kept, some noticeable improvement might begin to appear in 10 or 15 years.

"Still it would be uphill work and require time and patience to develop any considerable number of milch cattle, from animals averaging 2,000 lbs. of milk per annum to those giving 5,000 lbs. or more, which is about the lowest average outturn for a paying dairy animal, while the higher outturns so common in the West of 10,000, 12,000 or upwards will only come, if ever, in the far distant future.

"This line of work is so important that we consider Government should make a strong effort to interest the influential classes in scientific breeding and management of a superior type of dairy animals. The holding of cattle shows with prizes for dairy animals, the introduction of registration of animals which are of pure blood, the furnishing of assistance in procuring authentic records of performance, are the most obvious means for encouraging such work."

In the meantime the best buffaloes and cows should be selected from the leading breeds at present. The following extracts from the Report of the Committee of the Agricultural Conference at Coimbatore (December, 1913), on the Dairying Industry of India, summarise the most important improvements :—

"(1) That dairying as a branch of agricultural science, should, in future, occupy a prominent place in the programmes of the Agricultural Departments.

"(2) That sustained and systematic effort should be directed towards the improvement of milk-producing qualities of dairy cattle, both cows and buffaloes. The Committee are of opinion in this connection that there is no necessary conflict between draught and dairy qualities in cattle. It is, therefore, recommended that efforts should be directed to breeding what is known as the dual-purpose animal." With a view to this end the Committee recommended :—

"(*a*) That cattle-breeding farms at suitable centres should

be started with a view to increase the milking capacity of dairy cattle by selection and judicious crossing. Special attention should be paid to experimental feeding for the purpose of ascertaining what are the best fodders and foodstuffs for dairy cattle. A dairy school should be opened in each province at some important dairy centre for the training of persons who propose to engage in dairying.

"(*b*) That the supply of bulls on the premium system, or otherwise, to villagers should be encouraged.

"(*c*) That cultivators should be encouraged to grow crops which are specially fodder crops, and the distribution of free seed for this purpose should be considered.

"(*d*) That effort should be directed to educating the people on the practical side of cattle management and in particular to the profitableness of the dual-purpose animal.

"(*e*) That the question should be considered of establishing in the better cattle-breeding districts, milk record societies on the lines of the Danish "control" bodies in order that the selection of bulls of known quality may be made with certainty and the uselessness of inferior cows brought home to the breeder."

To this may be added two recommendations made to the Board of Agriculture in India by Milligan and Hutchinson,[1] namely: "(1) The necessity of early steps being taken by Government to secure the best milking animals in the country. (2) That the investigation of the inheritance of the important dairy characters of cows by crossing with imported bulls be undertaken by the Agricultural Department."

(*b*) **Feeding.**—Practical experience shows that milk production is dependent both in quality and quantity upon the amount of digestible food and on the presence of certain substances which stimulate the secretion of milk. Sufficient amounts of digestible proteins are essential for milk production. According to Ernst,[2] for 1,000 kgm. of body weight 1.212 kgm. of digestible proteins must be figured, together with a sufficient addition of fat and carbohydrates.

Morgen and Fingerling[3] found that the addition of certain substances (malt, buckhorn seed, hay distillate and fennel) to ordinary feed, stimulates the secretion of milk, although by them-

[1] *Journal of Dairy Farming in India*, Vol. I, Part 3, p. 197.
[2] Ernst's *Text Book of Milk Hygiene*, p. 133
[3] *Journal of Dairying*, Vol. I, Part 3, p. 234.

selves they cannot be utilised for milk production. Through the addition of salt to tasteless food an increased yield in the total amount of milk as well as in the fat was obtained, amounting to from 20.6 to 21.9 per cent.

The *amount of milk* yielded is influenced a good deal by *the character and amount of the feed* as well as by the "*inherent dairy qualities*" of the animal. We have already seen that succulent feeds have a very favourable influence on the milk secretion. As regards the amount of feed, this depends upon several factors, *e.g.*, the size and body weight of the animal, etc. Great differences are found in the amounts of food materials required by different cows and buffaloes. As a rule it has been found that good milk animals are large eaters and consume considerable quantities of grain feed as well as 'roughage.' *It is possible, however, to over-feed* so as to cause a marked increase in the weight of mature animals. This should be guarded against as it will be obtained at the expense of milk production. Experiments conducted by F. W. Woll[1] of the United States show that "about six pounds of grain feed per day produces more economical results than larger amounts, and is sufficient in the case of most cows to secure a maximum production of milk and butter-fat when the economy of the production is also considered, provided a supply of good roughage, hay, corn-stalks, silage or roots, is available." This is recommended as a general average for a herd of cows. In the case of large producers, however, as much as ten to twelve pounds of grain per day may be given.

The inherent dairy qualities of a cow.—According to Woll,[1] by this term is understood the faculty of a cow to utilise the food eaten for dairy purposes in such a manner as to respond to liberal feeding by yielding the largest amount of milk of which she is capable, without at the same time gaining materially in body weight. Woll found that the best American cows needed only 89 pounds of dry matter for each 100 pounds of milk they produced, and 20 pounds of solids for each pound of fat ; while the cows with medium production needed 105 and 24 pounds, and the poorest cows required 125 and 28 pounds, respectively, for the production of units of milk (100 lbs.) and butter-fat (1 lb.).

The cows producing the largest amounts of dairy-products were able to utilise their food to a better advantage than the cows

1 *Journal of Dairying*, Vol. I, Part 3. p. 230.

yielding medium or low amounts. Economic utilisation of food is therefore an important factor in determining the dairy value of an animal.

FEEDING STANDARDS.

In 1864, Dr. Emil Von Wolff presented for the first time[1] a table of feeding standards based on the digestible nutrients contained in feeding-stuffs. The Wolff standards soon found their way to America where further scientific investigations resulted in Armsby's and Haeker's Feeding Standards.

Haeker's Feeding Standard for the Dairy Cow.[2]

Daily allowance of digestible nutrients.

	Crude Protein. lbs.	Carbo-hydrates. lbs.	Fat lbs.
For *maintenance* of a cow weighing 1,000 lbs.	0.700	7.00	0.100
To the maintenance allowance add for each 1 lb. of milk containing 3.0 % Fat ..	0.040	0.19	0.015
,, 3.5 % ,, ..	0.042	0.21	0.016
,, 4.0 % ,, ..	0.047	0.23	0.018
,, 4.5 % ,, ..	0.049	0.26	0.020
,, 5.0 % ,, ..	0.051	0.27	0.021
,, 5.5 % ,, ..	0.054	0.29	0.022
,, 6.0 % ,, .	0.057	0.31	0.024
,, 6.5 % ,, ..	0.061	0.33	0.025
,, 7.0 % ,, ..	0.063	0.35	0.027

The table shows that if a cow is yielding milk containing 5 per cent. of butter-fat, she should be fed, *in addition to the maintenance ration*, on 0.051 lb. crude protein, 0.27 lb. carbohydrates, and 0.021 lb. fat, (all digestible) for each pound of milk she gives. For each 100 lbs. in body weight the cow may exceed or fall below the 1,000-lb. standard, there is added or subtracted one-tenth of the standard ration. Haeker's standard is used as a basis for feeding at the Poona Agricultural College Dairy.

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[1] Mentyel and Von Lengerke's *Agricultural Calendar for* 1864, (Paul Parey, Berlin).
[2] Henry, W. A. *Feeds and Feedings*, eleventh edition, 1911, p. 116.

Wolff-Lehmann Feeding Standard.[1]

	Per day per 1,000 lbs. Live Weight.				
	Total Dry matter. lb.	Digestible Nutrients. Protein. lb.	Digestible Nutrients. Carbo-hydrates. lb.	Digestible Nutrients. Fat. lb.	Nutritive ratio, 1 :
Milch Cows.					
When yielding daily :—					
11.0 pounds of Milk ..	25.0	1.6	10.0	0.3	6.7
16.6 ,, ,, ,, ..	27.0	2.0	11.0	0.4	6.0
22.0 ,, ,, ,, ..	29.0	2.5	13.0	0.5	5.7
27.5 ,, ,, ,, ..	32.0	3.3	13.0	0.8	4.5
Growing Cattle.					
Age (Months.) — Live weight.					
2-3 .. .. — 160 lbs...	23.0	4.2	13.0	2.0	4.2
3-6 .. .. — 330 ,, ..	24.0	3.5	12.8	1.5	4.7
6-12 .. — 550 ,, ..	25.0	2.5	13.2	0.7	6.0
12-18 .. — 750 ,, ..	24.0	2.0	12.5	0.5	6.8
18-24 .. — 950 ,, ..	24.0	1.8	12.0	0.4	7.2

Armsby's Feeding Standard.[2]

I—*Maintenance Standard.*

Live Weight (pounds)	Digestible protein. lb.	Energy Value. Therms.
150..	0.15	1.70
250..	0.20	2.40
500..	0.30	3.80
750..	0.40	4.95
1,000..	0.50	6.00
1,250..	0.60	7.00
1,500..	0.65	7.90

II—*Standard for Growing Cattle.*

Age (Months.)	Live Weight. lb.	Digestible protein. lb.	Energy Value. Therms.
3 ..	275	1.10	5.00
6 ..	425	1.30	6.00
12 ..	650	1.65	7.00
18 ..	850	1.70	7.50
24 ..	1,000	1.75	8.00
30 ..	1,100	1.65	8.00

[1] *Ibid*, Appendix, p. 591, etc.
[2] *Ibid*, p. 121.

III. The Armsby Standard for milk production.[1]

Add to the maintenance standard .05 lb. of digestible protein and 0.3 therm for each pound of 4 per cent. of milk to be produced. To illustrate Armsby's tables and standards in computing ration, suppose we have to find out feed requirements for a cow weighing 850 lbs.

1. The maintenance requirements are approximately digestible protein 0.45 lb. and energy value 5.60 therms.

2. For 20 lbs. milk production, in addition, the following would be needed :—Digestible protein 0.05 by 20=1 lb.

Energy value 0.3 therms by 20=6 therms.

The total daily feed requirements of a cow weighing 850 *lbs. and producing* 20 *lbs. milk daily would be :—*

	Digestible Protein.	Net Energy Value.
For Maintenance ..	0.45 lb.	5.60 therms.
For Milk production ..	1.00 lb.	6.00 ,,
Total requirements ..	1.45 lb.	11.60 ,,

Taking, then, a trial ration of different feeding-stuffs, calculations are made for the total amount of digestible protein and net energy value—the ration approaching nearest to the standard requirement is then given.

[1] The *Fuel Value of Nutrients* in terms of Therms is as follows :—

1 lb. Protein	=	1.86 Therms.
1 lb. Carbohydrates	=	1.86
1 lb. Fat	=	4.22

[TABLE.

TABLE I.—Indian Foods and Fodders.[1]

	Cotton-seed meal, Kirkee.	Cotton-seed, Kirkee	Cotton-seed, Belgaum.	Cotton-seed Hulls, Kirkee.	Groundnuts, Kirkee.	Oil, Cocoanut, Bangalore.	Gram, Kirkee.	Gram Bhusa, Bangalore.	Chooni, Kirkee.	Kulthi, Belgaum.	Bran, Kirkee.	Bran, Belgaum.	Barley, Kirkee.	Oats, Kirkee.	Atta Sweepings, rice, Kirkee.
Moisture % ..	7.28	7.21	8.44	8.32	7.47	11.47	9.47	9.36	9.77	10.36	9.07	10.82	10.32	5.99	9.64
Oil % ..	8.86	19.59	18.37	5.20	11.78	12.35	4.05	0.89	0.96	0.92	4.11	3.17	2.26	5.87	2.59
Albuminoid %..	28.33	17.06	15.04	6.52	43.91	20.07	20.56	4.47	18.25	20.12	11.93	11.39	7.73	8.64	9.26
Soluble Carbo-hydrates %..	38.60	33.48	36.42	49.58	27.65	42.99	57.18	40.33	59.17	60.31	62.22	61.69	73.2	62.34	74.17
Woody fibre %..	9.98	16.67	17.61	26.95	3.04	7.02	5.71	40.40	3.95	4.42	6.32	8.12	4.49	12.11	1.51
Soluble mineral matter %..	6.17	4.25	3.96	3.29	4.40	5.10	2.90	4.24	5.21	3.37	4.80	4.64	1.71	1.85	1.74
Sand % .	0.78	1.04	0.16	0.14	1.75	1.00	0.13	0.31	2.69	0.50	1.55	0.17	0.47	3.20	1.09
Total ..	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Nitrogen { Total ..	4.69	2.90	2.65	1.09	3.32	5.55	3.55	0.75	3.26	3.68	2.08	2.02	1.31	1.51	1.59
Nitrogen { Albuminoid..	4.53	2.73	2.40	1.04	3.03	3.21	3.29	0.71	2.92	3.22	1.91	1.82	1.24	1.38	1.48
Food Units ..	131.4	125.3	120.1	78.2	166.7	123.0	180.7	53.8	107.2	112.9	102.3	98.2	97.9	98.6	103.48

[1] Kindly supplied by Dr. H. H. Mann from analyses made at the Poona College of Agriculture.

TABLE II.—Indian Foods and Fodders.

Composition.	Bengal gram (Cicer arietinum.)	Guvar, common variety used for cattle food, (Cyamopsis psora lioides).	Vatana, white; Indian peas.—(Pisum sativus).	Vatana, black; Indian peas (Pisum sativus).	Masur, Lentil (Ervumlens).	Kulthi, or horse gram (Dolichos uniflorus).	Lang. (Lathyrus sativus).	Chola, (Dolichos catiang).	Mug, (Phaseolus mungo).	Udid, (Phaseolus radiatus).	Val, (Dolichos-lablab).	Math, (Phaseolus aconitifolius).	Tur, (Cajanus indicus).
Moisture	11.35	8.63	12.05	11.25	8.03	7.45	7.89	7.26	9.48	8.14	7.11	8.59	8.08
Oil	4.83	2.29	1.27	1.47	1.06	0.89	0.79	1.35	1.83	0.99	0.93	1.07	1.32
Albuminoids	18.57	18.81	24.12	24.69	23.00	20.06	24.69	20.13	23.56	18.50	23.31	22.50	19.38
Soluble Carbohydrates ..	56.33	55.50	54.44	52.47	61.14	60.62	57.98	63.30	56.39	59.11	56.98	58.85	61.39
Woody Fibre	6.17	10.96	5.47	6.67	2.42	4.57	4.28	4.07	4.42	4.33	6.94	4.24	5.94
Ash	2.75	3.81	2.65	3.45	4.35	6.41	4.37	3.89	4.32	[2]8.93	4.73	4.75	3.89

[1] Analyses by Dr. Leather, quoted in Mollison's *Text-Book of Indian Agriculture*, Vol. II, p. 114.

[2] Sand 4.2.

TABLE III.—Average Analysis of the Principal Indian Fodders.[1]

		Percentage Composition.										Percentage of Digestible Constituents.			
		Moisture.	Oil.	Albuminoids.	Carbohydrates.	Woody-fibre.	Ash.		Total dry matter per 100lbs. Without sand.	Sand in ash. %	Digestible Oil %	Digestible Albuminoids. %	Digestible Carbohydrates. %	Total Food Units per 100.	Heat production (per 100 lbs).
Cottonseed Hulls.	%	10.00	1.50	5.25	47.00	30.50	5.75	lbs.	90	0.25	1.39	4.20	30.55	44.5	70.5
Dry Jowar Karbi.	%	8.00	1.00	2.80	44.00	35.00	9.20	,,	88	4.25	0.35	0.84	22.00	24.9	44.0
Hay.	%	6.20	1.10	3.20	44.00	32.20	13.30	,,	84	10.00	0.38	0.96	22.00	25.3	44.3
Green Jowar Karbi.	%	65.00	1.20	3.60	16.00	11.70	2.50	,,	34	1.00	0.42	1.08	8.00	11.7	18.6
Green Maize Karbi,	%	66 50	1.40	4.00	14.00	10.30	3.8	,,	34	0.50	0.49	1.20	7.00	11.22	17.3
Silage.	%	64.00	1.17	3.50	11.33	14.00	6.00	,,	34	2.00	0.41	1.05	5.66	9.31	14.2

[1] *Journal or Dairying*, Vol. I, Part 2, p. 114.

The balanced ration is only a theoretical possibility and can only be approximated in practice. It will be evident from the above that Armsby's Standard is very high, while Haeker's Standard is the lowest. It would be well to begin with feeding according to Haeker's Standard and then gradually increase it as may be necessary. The accompanying Tables give the analytical figures of some of the foodstuffs used in Bombay, Poona and Western India. The digestible nutrients in Indian foodstuffs as well as their available energy have not been worked out as yet. The digestible co-efficient for similar foodstuffs in Europe and in America has been found to range between 60 and 70 %, or about two-thirds of the total, and this may be assumed as a working basis for feeding in India. Mr. E. W. Horne, Manager, Poona Agricultural College Dairy, gives the following figures for the *approximate net available energy on fuel value* in various foodstuffs :—

Roots, 34 %; Green Fodders, 30%; Dry Fodders, 22 %; Straws (of wheat, oats, etc.), 12 %; Grains, 50 %; Oil cakes and meals, Corn meal, etc., 45 %; and Wheat Bran, 30 %.

Owing to the various types of milch cattle in India and their individual differences, it is not possible to make up a fixed ration which would be suitable under all conditions. The ration for each animal varies according to its body weight and the quantity and quality of its milk. Dry animals need only a *maintenance* ration while those in lactation need an additional allowance for *milk production.* The usual feed given to milch cattle in Bombay has been mentioned in Chapter V.

Meagher and Vaughan[1] mention the following as the ordinary quantity consumed daily by a cow in full milk :— Bhusi (a mixture of gram, bhusi, and urid bhusi). 6 lbs.; linseed cake, 4 lbs.; green fodder, 40 to 50 lbs.; or hay, 20 lbs. To this, one pound of cottonseed should be added when the milk is intended for butter-making. A buffalo in full milk will usually require two pounds more of each class of concentrated food (bhusi, 8 lbs.; linseed cake, 6 lbs.; and cottonseed, 2 lbs.). Mollison mentions the following ration per day for a buffalo that is newly calved :—8 to 12 lbs. of good hay, 15 lbs. of green grass or other green fodder, 5 lbs. bran, 5 lbs. bajri (*Pennisetum typhoideum*), 2 ozs. salt, (as a hot mash). When the period of lactation is somewhat advanced, a change should be made

[1] Majors D. J. Meagher and R. E. Vaughan, "Dairy Farming in India," 1904, p. 2.

in the ration according to the size and weight of the animal and the average yield of milk. For a buffalo of the average size and weight giving 18 lbs. of milk per day and suckling her calf, the following ration is recommended by Mollison :—

Green fodder, 10 to 15 lbs. per day	chaffed together if possible.
Dry fodder ,, ,,	
Cottonseed	3 lbs per day.
Bran	3 ,, ,,
Sesamum oil cake	3 ,, ,,
Chuni (husks of *cajanus indicus*) ..)	2 ,, ,,
Salt	1 to 2 ozs.

A cow should receive about two-thirds of the above rations. The food should be cleansed of all dust, etc., and be made more palatable by adding salt. It should be also made more digestible by crushing coarse food into a finely granular condition. Cooking may be desirable in the case of bajri, etc. Chaffing of straw or hay is advisable ; chaffing coarse fodder, *e.g.*, dry jawari stalks with a certain proportion of the green jawari stalks or with green lucerne is also recommended. Care should be taken to give palatable food and to effect economy at the same time. Waste in the stables should be prevented.

At the Government Military Dairy, Kirkee, the feed is based upon the yield of milk. The animals are divided into three classes and are given the following scale of rations :—

	Cotton-seed meal.	Cotton-seed hulls.	Ground nut cake.	Tur-Chuni or Gram.	Salt.	Hay.	Remarks.
First class. (The yield is 20 lbs. and over per day) ..	2 lbs.	8 lbs.	3 lbs.	2 lbs.	2 oz.	40 lbs.	This ration is given during the Monsoon.
Second class. (Daily yield 10-20 lbs.) ..	2 lbs.	6 lbs	2 lbs.	2 lbs.	2 oz.	35 lbs.	
Third class. (Daily yield below 10 lbs.) ..	2 lbs.	5 lbs.	2 lbs.	1 lb.	2 oz.	30 lbs.	

The amount of concentrated food for the Indian milch cattle may be calculated at two-thirds the yield of milk of an individual animal. According to Shevade,[1] this may be considered as a safe guide for practical purposes.

According to Mollison,[2] fodder obtained from stalks and leaves yet green is much more nutritious than that from a crop which has been allowed to fully ripen, because as the plant ripens the carbohydrates and albuminoids are largely transferred from the stem and leaves to the fruit. The best fodder is obtained from a crop when in flower. At this stage the fodder has nearly attained its maximum bulk, and the albuminoids, oils and carbohydrates are distributed more or less through the substance of the stalks and leaves, whereas when the crop is ripe they collect for the most part in the fruit or seed, and the cellulose becomes less digestible or is converted into indigestible crude fibre.

The fodder of some crops has a much higher feeding value than that of others. The fodder of pulse crops furnishes more concentrated food than the fodder of cereal crops. The seeds of all the pulse crops provide a far more concentrated food than the grain of wheat, jawari, maize or other cereal. The oilseeds are, as to richness in albuminoids, intermediate between pulses and the grains of cereal. Oil-cakes are the residues left when oil is expressed from oil-seed, and there is a relatively higher percentage of albuminoids in oil-cake than in oil-seed. Oil-cakes are generally more concentrated than any other kind of food.

An adequate supply of cheap fodder of good quality and an abundant *supply of good water* are essentials for the rearing of milch cattle along economic lines. The water-supply must be pure, sufficient and convenient to reach. The scarcity of water and of green fodder in the Deccan account to a great extent for the poor breeds of milch cattle there. Moderately liberal feeding with suitable food is important for improving the milking properties of the Indian stock. The question of improving fodder crops for soiling, silage and hay was discussed at the second Conference of Government Dairy Farm Managers held in Poona (1914). It was pointed out that for profitable dairying it is necessary to secure good land near the dairy to be used for modern "intensive farming" or the cultivation of green crops, so that the valuable solid and liquid manures could be intelligently utilised for producing succulent food for the cattle during the

[1] Mr. S. V. Shevade, B.Sc., etc., in a personal communication.
[2] Mollison. "Text-Book on Indian Agriculture" Vol. II, p. 17.

whole year. "Undoubtedly with the many facilities for manuring, irrigation, extensive improvements, etc., a perfect system of fodder crop cultivation could be followed on the most approved intensive system, with such crops as maize, jawar, lucerne, burseem, cowpeas, guinea grass, rye and rye grasses both alone and in combination."[1]

(*c*) **The housing, tending, etc., of milch cattle.**—The following are the essential points to be observed regarding milch cattle stables :—

1. They should be so located as to ensure the best possible sanitary surroundings, and so constructed as to prevent wastage of fodder and of manure.
2. They should afford protection from the sun, rain, and wind.
3. They should be convenient and effect an economy of labour.
4. The cost of construction must be as low as is compatible with the sanitary and economic requirements.
5. A pure water-supply must be available for the cattle.
6. In the case of city stables, they should fulfil all the structural requirements from a sanitary point of view (see pages........).

The location of milch cattle stables in cities is considered to have some advantages and a great many disadvantages from an economic as well as from a sanitary point of view. In the first place *it is expensive* as the rents in the city are very high. Secondly, fodder and grain have to be stored and conveyed to the city which means an additional expense. Thirdly, in the city, milch cattle do not get proper exercise in the open air but are in unnatural surroundings which are not very conducive to good yields of milk. Besides, the manure is practically wasted, or if collected and sent to the country, it would cost a good deal. On the other hand, in the country the manure could be utilised in raising fodder for the cattle. A further disadvantage of housing cattle in the city is that they are generally kept in the midst of very insanitary surroundings. The filthy condition of the cattle stables in Bombay has been already described. In the crowded areas of the city they constitute a danger to human beings residing in the immediate neighbourhood. In the case of an epidemic, say, of enteric or cholera, there is a great danger of contamination of the milk supply from the city stables. The

[1] *Jour. of Dairying*, Vol. I, Part III, p. 239.

main advantages of having cattle stables in the city are, that they could be easily supervised, there is better provision for water supply and drainage, and that milk would not have to be conveyed very far to the consumer. It is possible besides to have the cattle milked in one's presence. The chief disadvantages of housing the milch cattle outside the city would be the lack of proper supervision and the difficulty of cheap and rapid transit to the city. Besides, the water-supply may not be pure and adequate. These difficulties could be, however, overcome by the extension of sanitary control to the suburbs and by the provision of rapid and cheap means of transit. On the other hand, the advantages of keeping milch cattle in the country are many, both from a sanitary as well as from an economic standpoint. As pointed out already, it is much more economical to rear cattle on a country farm than in a large city. The evil of slaughtering dry milch cattle in the large cities would be minimised by keeping them in the country. It would be cheaper to cultivate one's own fodder crop by utilising the solid and liquid manures. There would be plenty of fresh air and some grazing. On the whole the surroundings being natural and more healthy than in the city, it would conduce to better health of the cattle, and therefore, better yield of milk in the country than in the city. It would be cheaper to construct ordinary cattle sheds in the country than to erect elaborate stables in the city, where the price of land also is very high. As has been already stated, the trained cultivator is the proper man to undertake the breeding and rearing of cattle. Provision must be made, of course, for an adequate supply of pure water. In cases of an epidemic it would be much easier to segregate cattle in the country than in the city. The advantages and disadvantages of having milch cattle in the city and in the country may be summed up as follows : —

(A) In the City.

Advantages.	*Disadvantages.*
1. Proper sanitary supervision and legislative control.	1. Higher rents for stables, etc.
2. Easier access. The milk has not to be transported a long distance.	2. Feeding more expensive.
	3. Lack of exercise and fresh air which are important for a good yield of milk.
	4. Waste of valuable manure.

(A) In the City.—(*contd.*)

Advantages.	*Disadvantages.*
3. Greater likelihood of a pure and abundant supply of water, and better drainage.	5. Insanitary and unhealthy surroundings for the cattle.
	6. Nuisance or danger to human dwellings in the neighbourhood.
	7. Too expensive for keeping dry animals and raising young stock. This leads to the slaughter of the dry animals and neglect in the rearing of calves.
	8. Milk is more likely to be contaminated with dirt, dust, bacteria, etc.

(B) In the Country.

Advantages.	*Disadvantages.*
1. More economical.	1. Lack of proper sanitary supervision and control.
2. Possible to raise one's own fodder.	2. The water-supply is likely to be scanty and bad.
3. Grazing and exercise in the fresh air which slightly improve the yield of milk.	3. The chances of adulteration with water during transit are perhaps greater.
4. Manure can be utilised for "intensive" farming.	4. The cost of preserving milk (by pasteurisation, etc.,) for long distances, and the difficulty of rapid and cheap transit to the city.
5. More natural and healthy surroundings.	
6. In epidemics, isolation of cattle is easier.	
7. Milk is less likely to be contaminated with pathogenic bacteria, dirt, and dust.	
8. The taste of the milk is better in the country than in the city.	
9. Scientific breeding can be undertaken.	
10. Cheaper to maintain dry animals and raise young stock.	

The concensus of opinion of dairy experts in India is decidedly in favour of keeping the milch cattle in the country, particularly in the suburban villages near the railway line, within convenient distance from the city. This would be the most economic method of milk production in this country.

As regards the tending of animals, it appears that a milch animal will give better results in the hands of a careful *gowlee*, or village cultivator, who personally looks after the animal, than in the case of a large commercial dairy farm where it is treated as "one of the herd." This is the experience, for instance, of the Agricultural College Dairy at Poona, where there is a tendency for the yield to fall off in subsequent periods of lactation. Both the feeding and housing there are superior to what is usually obtained in India, and so the falling off can be attributed only to bad tending. The men usually employed in the large commercial dairy farms have usually very little interest in the well-being of the cattle, and being only "hired labourers" are inclined to be careless in their tending. The animals need to be fed and watered at regular intervals. The buffaloes need daily washing, while the cows need greater protection from the inclemencies of weather, etc. Every effort should be made to make the animals as comfortable as possible. Regular exercise in the open air is conducive to better health of the cattle and better yield of milk. Grazing, although desirable, is not absolutely essential for milk-production, provided that the cattle are well fed in the stalls and are allowed a reasonable amount of exercise in the open air.

There is a conflict of opinions as regards the comparative value of open grazing and stall-feeding in this country. One of the reasons given against stall-feeding is that it hinders the development of limbs and muscle and produces dwarf cattle. This is, however, very doubtful in face of the fact that one of the best breeds of cattle, *viz.*, Krishna Valley cattle, is almost entirely stall-fed. In the Bombay Presidency, in addition to overstocking, grazing is scarce from February to June, when there is hardly any grass to be found. During this period no advantage would be gained by the cattle wandering about for long distances without shelter and without water.

(B) Other measures to counteract the deterioration of milch cattle.

Besides the improvement in breeding, feeding, housing and tending, other measures are also necessary. These may be now briefly considered.

As stated in Chapter II, during the famine of 1899-1900, there was a considerable loss in the number of milch cattle in the Bombay Presidency. While it is true that famines eliminate many useless cattle, there is no doubt that many good milch cattle also perish during famines for want of fodder and scarcity of water. *The remedy would consist in making ample provision for the supply of good water and for a large storage of fodder, both dry and in the form of ensilage.* Even in ordinary times the cultivators find it very difficult to obtain the necessary supply of fodder and water during the dry season, particularly towards the end of the dry season. Even in the best milk-producing districts of Gujarat there is a drop in milk production of 20 to 30 per cent. during the months of March to June. In other parts it is a common experience to find a considerable falling off in the milk supply soon after the supply of green grass is exhausted. On the other hand, during the rains, there being an abundant supply of fodder, the cattle are likely to be overfed. This has some bearing on the questions of grazing and breeding.

In the old days when the tendency for the grazing grounds to be overstocked was less than at present, grazing of cattle on common grazing grounds was not absolutely satisfactory, for the animals were very well fed during the rains but had almost to starve during the dry season.

A very favourable condition for good cattle breeding is that in which the grazing and the supply of stored fodder are abundant. A very instructive example of a combination of common grazing and stall-feeding is the case of the *Khillari cattle*, which are bred in the Sangola and Man Talukas and in the Ahmednagar district. These places consist mainly of rough stony hills and lands with a light and thin soil. These districts are not very profitable from an agricultural point of view but afford a vast area of grazing grounds during the wet season and sufficient fodder for the dry season. In the open plains where the main crop is cotton and where the only fodder available is the jawari

kadbi or the bajri *sarmad*, profitable cattle breeding is found to be a great failure[1].

Common grazing is no doubt a great convenience to small holders, but it cannot be considered a very economical practice, for it is certain that good land can produce more fodder to the acre under cultivation than under the neglected condition of the common grazing ground.

The necessity for an abundant supply of good water has been already emphasised. What is required is *better irrigation*, particularly in some of the districts in the Deccan, without which it would not be possible to produce an adequate amount of green fodder.

As pointed out in Chapter II, the slaughter of dry animals in large cities accounts to some extent for the diminution in the number of good milch cattle. In support of this statement figures have been cited from the slaughter houses in Bombay and Calcutta, which show that thousands of good milch animals are annually slaughtered in these two cities. A similar state of affairs is known to exsit in a few other large cities also. It appears that in Bombay there is a demand for buffalo meat among certain classes of the population and for use on some ships. It also appears that in the rural districts adjoining Bombay, there is a considerable number of unprofitable buffaloes which might be very well used to meet this demand. It is, therefore, very unfortunate that a large number of valuable milk buffaloes from the Bombay cattle stables should be allowed to go to the butcher year after year. This is one of the principal evils of keeping milch animals in the city, where it is not possible to maintain dry animals profitably. It is very difficult to propose practical remedies for the mitigation of this evil. It is suggested that in Bombay at least this might be minimised by (1) arranging for the import of buffalo meat into Bombay from the rural districts; (2) organising or facilitating the export of valuable dry buffaloes from Bombay to the grazing districts, and (3) locating the milch animals outside the city and importing milk from a distance by trains, etc. If these remedies are not found to work satisfactorily then it may be necessary to resort finally to legislation. Measures may be also taken to limit the export of the best breeds of Indian milch cattle to foreign countries.

[1] I am indebted to Mr. G. F. Keatinge. C.I.E., I.C.S., Director of Agriculture. Bombay, for this information.

A very important point in the improvement of the milk stock is the *care of the young calf.* As mentioned in Chapter II the city *gowlee* wants only the milk and not the calf, which he is unable to rear profitably. This is specially the case with buffalo calves, and means a serious loss to the country of a large number of calves of the best milk buffaloes. Exceptionally one comes across a city cattle stable where calves are actually reared,[1] but as a rule, they are allowed to die of neglect and in some places they are even thrown alive into a dust-bin. The only practical remedy seems to be the *emigration* of the city *gowlee* to the suburbs where he could rear the calves with profit. The details of the management of calves can be found in many text-books.[2]

(C) Reforms in the existing methods of collection, transport and distribution of milk.—These will be considered mostly from the economic point of view,—the sanitary methods will be discussed in the next section. As pointed out in Chapter I, the method of milking is peculiar to India in several respects and needs improvement. The calf is allowed to have nearly half the amount of milk and this loss should be minimised as far as possible. In the case of buffaloes at least, it has been found to be unnecessary to first let the calf have its milk in order to obtain the maximum yield. Milking vessels, etc., of improved material and pattern would be necessary.

Transport of milk.

The question of transport of milk is intimately connected with its *keeping qualities* under Indian conditions of climate and the *facilities for transit.* The amount of time elapsing between milking and delivery to the consumer is of considerable importance. The keeping qualities of milk would depend upon: (1) the care exercised during milking, (2) the manner in which milk is handled from its production to delivery, (3) the temperature at which it is held, and (4) the distance to which it is to be conveyed, or rather the amount of time required for transit. It has been already pointed out in Chapter V that the keeping qualities of milk practically depend on its bacterial content. The keeping quality of milk and its transport in Central India have been studied recently by Robert G. Allan and J. V. Takle.[3] They conducted a series of experiments in Nagpur. Their observations regarding the keeping quality of milk included: (*a*)

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[1] I have come across a dairy farm in Bombay where this is being done.
[2] Also see the *Journal of Dairying and Dairy Farming in India,* Vol. I, Part III, p. 243.
[3] "Agricultural Journal of India," Oct. 1915. Vol. X, Part IV, p. 329.

a comparison of the effect of the different milking methods, (*b*) a comparison of the effects of different conditions under which the milk was kept after milking, (*c*) a comparison of different methods of treating milk produced and kept under varying conditions. They made further observations with regard to the conditions and causes of butter formation frequently found during the transport of milk, and the means for its prevention.

The following are some of their conclusions:—

(1) Care and scrupulous cleanliness at the time of milking will add several hours to the life of the milk. Sterilisation of the milk vessels, apart from mere washing, is important.

(2) During transport by rail, chilling to 40°F and keeping it at that temperature will preserve the milk for 10 to 12 hours after milking.

(3) Under conditions of road transport by cart or motor-lorry over rough roads there is a tendency to butter-formation, particularly in raw buffalo-milk during the cold weather.

(4) The tendency to form butter varies with: (*a*) the temperature at which the milk is transported, butter being formed in all cases below 90°F, but never above 105° F; (*b*) the degree of fullness of the milk churn, being less if the churn is quite full; (*c*) the time interval, the amount of butter being greater the longer the time; (*d*) the kind of milk transported, more butter being formed in buffaloes' than in cows' milk.

(5) The best treatment for all milk carried by road over any distance is pasteurisation at the milking centre to 140° — 160° before issue, dependent on time of transport and temperature, and its subsequent chilling on its receipt at the city depot before retail issue.

If milk can be delivered within a short time after milking it would not require any special treatment to prolong its life. When the time-interval, however, exceeds three to five hours (varying according to temperature, conditions of collection, etc.), the milk would have to be preserved by one of the following methods—cooling or refrigeration, pasteurisation, boiling or sterilisation.

For commercial purposes the choice would be between refrigeration, pasteurisation and sterilisation, while, for domestic purposes, boiling is the cheapest and most efficient method. Most people would prefer to have fresh (raw) milk, and refrigeration would meet this demand if it were not for the high cost at which

milk can be cooled in this climate. Another disadvantage of this method is that under the present conditions there is no guarantee of obtaining milk free from contamination. Pasteurisation and sterilisation, on the other hand, are known to be effective precautions. Sterilisation has been tried to some extent in this country but it is reported that the cost is too high for commercial purposes. Pasteurisation seems to be the only practical method from an economic point of view, the cost of pasteurisation in India, apart from the initial expenses for the plant, etc., being only about 1½ pie per pound. The details of the cost of pasteurisation are given in Appendix A. The advantages and disadvantages of pasteurisation and the comparative value of refrigeration, sterilisation, boiling, etc., will be discussed under " Sanitary Measures."

Facilities for transit.

The present methods of conveying milk in some of the Indian cities have been already described. The most common method is carrying milk by hand. It is less frequently conveyed by slow carts, and in Karachi by camels.[1] In large cities, *e.g.*, Bombay, modern methods, *e.g.*, horse and motor waggons, are being gradually introduced. The transport of milk in suburban trains involves the employment of a very large number of men. The present methods of conveying milk to the city of Bombay have been described in Chapter II. The facilities for transit should be so improved as to effect a saving in time and labour. In other words, the transit should be rapid and cheap. A complete change is needed in every way. More trains, more speed, a reduction in the rates, special equipment for conveying milk, better kinds of cans or milk vessels, provision for maintaining a low temperature during transit, etc., are some of the principal reforms needed. It is very essential that the milk must reach the consumer as soon as practicable after milking so as to be in as fresh a condition as possible. For short distances (within 10 miles) the use of motor or horse waggons, and for long distances (10 to 100 miles or more,) railway trains are the most convenient. At present, motor waggons are being used by two or three large dairying concerns in Bombay. The two railway companies in Bombay do not provide any specially equipped milk trains or milk-cars or vans at present. Milk is conveyed like any other article in the ordinary " luggage vans " or " brake vans." The rates charged

[1] " Agricultural Journal of India," Vol. X, No. IV, p. 401.

at present are two annas per maund (two pence or four cents. for 80 lbs.) for any distance not exceeding twenty-five miles, and thereafter one anna for each additional twenty-five miles. Special milk-cars with refrigerating arrangements are desirable, but this would considerably increase the cost of transit and consequently also cause a rise in the price of milk. Unless there is a reasonable certainty of sufficient and regular milk traffic, it may not be possible for the railway companies to make the necessary improvements for the conveyance of milk without raising the existing rates. If the milk trade was organised in a systematic way on a sound business basis, and if the railway companies were assured of a permanent and regular transit of a large quantity of milk, I daresay they would be quite prepared to meet all the demands.

The distribution of milk in the cities.

The purveying of milk after its arrival in the city offers somewhat a difficult problem. Milk being a perishable article, it must be sold to consumers with the least possible delay. Most purveyors mix the various consignments of imported milk before sale (Plate XXVII). Some of the importers in Bombay sell their milk out of the original containers, which are usually brass *lotas* (Plates XXII and XXIII). The kind of milk vessels recommended, the use of the milk-bottle for India, etc., will be discussed under "Sanitary Measures," (*q.v.*)

The business of importing milk into Indian cities is mostly in the hands of numerous small dealers. In Bombay there are nearly 450 importers and 1,500 men are employed for bringing in about 45,000 pounds of milk daily. It would be much easier to control, educate and supervise a few large firms of importers than hundreds of small dealers. What is required for the efficient distribution of milk in our cities is concentration. A few organised concerns on a large scale would be far more desirable than numerous petty milk-dealers from the economic, sanitary, as well as from the administrative point of view. This would greatly facilitate the work of the Public Health Department. A smaller number of milk inspectors would be required. It would certainly be an economic arrangement both for the purveyor as well as for the consumer of milk. The large concerns could afford to purchase expensive sterilisers, pasteurisers, bottle-washing machines, motor and horse-waggons, etc., etc. They could also afford to employ trained and competent assistants. Another

point in favour of having a few large importers is that they could readily meet the fluctuating demand for milk in the market and profitably utilise the surplus of milk by converting it into butter, curds, butter-milk, etc.

The two agencies suggested for the purpose of organising the collection and distribution of milk are: (1) co-operative dairy societies; and (2) private dairying concerns on a large scale.

(1) Co-operative dairy societies.

The idea of co-operative dairying originated first in Switzerland in the village of Kiesen, near Berne, in 1815, just a hundred years ago. Denmark took up co-operative dairying some sixty-five years later. Since then it has spread all over Europe and the United States of America. The practical benefits accruing from co-operation have been amply demonstrated in these countries. In the United Kingdom in 1912 there were only about a score of co-operative dairies as compared to about 3,500 in Germany, about 2,000 in Switzerland, 1,200 in Denmark, 700 in France and 400 in Ireland.[1]

It would be beyond the scope of this memoir to enter into the minutiæ of the management of a co-operative dairy. A few important points, with special reference to conditions in India, will be, however, considered. Broadly speaking, there are two essential requirements for a co-operative dairy, namely: (1) a regular and sufficient supply of pure milk; and (2) the securing and retention of a favourable and reliable market. In order to meet the first requirement there should be a binding obligation upon all the members of the society to maintain an adequate number of good milch cattle and to deliver regularly all the milk which is produced by the animals. The obligation should be for a number of years (5 to 15), or else the society may find itself at a loss with an expensive plant and buildings on their hands. The possession of a good market would depend a good deal on the proximity to a populous city and on the means of rapid transit. The distribution of milk also might be done by co-operation.

The co-operative movement was started in India about twelve years ago. To-day we have more than 15,000 co-operative credit societies with a total membership of more than seven lakhs (700,000) and a working capital of over 77 million rupees. In the Bombay Presidency the progress of co-operative credit has been

[1] Henry W. Wolff. "Co-operation in Agriculture," 1912, p. 82.

satisfactory, there being more than 700 societies numbering over 68,000 persons and with a working capital of nearly 66 lakhs.[1] The organisation of co-operative dairy societies in this country has been attempted recently in Lucknow, Benares[2], Central Provinces, Punjab, and in some parts of the Bombay Presidency such as Belgaum, Hubli, Bhandup, Alibag and Thana.

Mr. V. H. Gonehalli, the Assistant Registrar of Co-operative Societies, Bombay Presidency, briefly summarises the co-operative scheme as follows :—

"I would urge that the gowlees keeping milch cattle in a town should be induced to keep their cattle outside the town ; that the Municipality should provide them with stables outside the town on a suitable site having water-supply and grazing facilities ; that the gowlees should be organised into a co-operative dairy society ; that the society should grant them loans for purchasing animals and foodstuffs ; that it should organise the joint purchase of foodstuffs for the members ; that milking should be done in the presence of the secretary of the society; that the ordinary simple sanitary rules as regards washing the udders of animals, the hands of milkers and the utensils used in drawing, storing, transporting and distributing milk should be observed; and that the marketing of milk should be taken away from individual producers and entrusted to the managing committee of the society."

The production of milk in the cities has been shown to be very expensive and insanitary. The city gowlee works under the greatest disadvantages, as he has to pay high rents for the cattle stables and high prices for foodstuffs, and in addition, he borrows money from the *Marwaris* (usurers) at exorbitant rates of interest. It is no wonder, therefore, that he tries to make up for this loss by raising the price of milk and adulterating it with water. *The organisation of the gowlees into one or more co-operative societies* and inducing them to stay outside the city limits would help a great deal in solving the economic side of the problem. By joining a co-operative dairy society the gowlee will gain in many ways : (1) he will be able to get loans at a lower rate of interest and on easy terms of repayment ; (2) he will be able to purchase foodstuffs of superior quality at a moderate price ; (3) the animals being kept under sanitary conditions and properly

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[1] Report of a lecture by Mr. V. H. Gonehalli, in the *Times of India*, dated 29th July, 1915.
[2] "The Journal of Dairying," Vol. I, Part I, October, 1913, p. 25.

cared for, will improve in health; (4) the yield of milk will be somewhat greater than under city conditions; (5) there would be an improvement in the breeding, as the society could maintain one or more superior breeding bulls; (6) the society will be able to take up a plot of land in the vicinity of the stables and grow fodder crops, utilising all the stable manure which would be otherwise wasted in the city stables; (7) the dry cattle could be kept at a small cost outside the towns—instead of finding their way to the city butcher, as at present; and (8) the cost of marketing milk in the city would be proportionately diminished, as the society could market their milk in bulk and employ modern methods of rapid transit, such as horse and motor-waggons, etc.

The second great source of the city milk supply is from the suburban villages, as fully described in Chapter II. It would be desirable to start *co-operative dairy societies among the village cultivators* along similar lines as indicated above. The ordinary village cultivator in India is usually poor and ignorant and often held fast in the clutches of the *savakar* (money-lender). It would be very difficult to convince him of the benefits of modern methods of breeding and dairy-farming. The average Indian agriculturist is usually careless in his methods of breeding. He generally owns very few animals and cannot maintain a proper bull of his own, but has to be satisfied with any nondescript animal that happens to be kept in the village. He lacks both ambition as well as money. The agriculturist has, however, the advantage of being able to grow enough of fodder on his own land for the use of his animals. He cannot be expected to improve on the old methods of milk production unless it is done for him by a co-operative society or some such body under proper supervision. In the villages which provide milk to the cities, central milking sheds might be constructed. The cultivators who are members of the local co-operative society could bring their buffaloes and cows to this shed daily at the appointed hours, draw milk in the presence of the manager of the society and then hand over measured quantities of milk to the committee, who should make the necessary arrangements for the transport and marketing of the milk, either directly or through some private agency. In addition to the advantages mentioned above, a village co-operative dairy society would be the means of improving the general condition of the village

cultivator, as dairying would form only a subsidiary industry and an additional source of income. Such societies could be very well utilised in course of time for scientific breeding of milch cattle.

The co-operative societies in this country are still in their infancy. They would be very valuable at present in the collection of milk from the cultivators, the supervision of the milking, and gradually improving the breed of the village animals. They would be also the means of educating the agriculturist in modern methods of dairy-farming.

The scheme outlined above is not quite a new one and has been found to work satisfactorily in actual practice. Mr. Gonehalli informs me that in the Bombay Presidency co-operative dairying has been tried with success in Thana and Alibag, and similar schemes are under preparation or execution at Belgaum, Bhusawal, Hubli, Bhandup and Ahmedabad. (*Vide* Appendix B.)

(2) **Private dairying concerns.**—Private concerns with large capital could profitably take up the city milk trade and employ experts and competent dairymen and use modern methods for the importation and distribution of pure milk. So far as possible, however, all *monopoly* should be discouraged and the existing milkmen (gowlees, etc.,) should not be absolutely deprived of their hereditary occupation. They may be employed in the large concerns or be formed into co-operative dairy societies.

The experience of Government Military Dairies and others in India seems to show that under the existing conditions it is not generally profitable for private concerns to undertake the *production* of milk, but the business of purchasing milk from the indigenous producer in the rural districts and sending it to the city for sale is found to be a lucrative one. In other words, it appears that in the case of large commercial dairies, *dairying* always pays but dairy *farming* seldom. It may be stated that there are a few dairy-farming concerns in the Bombay Presidency, but the production of milk by such concerns has been found to be more expensive than that by the small village cultivator. The most economic source of milk supply for cities is to be found in the villages where the cultivator maintains his cattle under cheap and natural conditions. This is seen, for instance, in many of the districts in Gujarat. The milk supply of the large cities of Europe and America also is usually obtained from the country by large contractors or "middlemen" who buy the milk from

the farmer and bring it to the city for sale. The private dairying concerns proposed for this country would practically occupy the position of "middlemen." Such concerns are likely to be more suitable than co-operative dairies, at present, for the purpose of importing milk from long distances and marketing it on a large scale.

The two agencies described above would greatly facilitate sanitary and legal control, as there would be only a few organised concerns to deal with instead of numerous small dealers. Moreover, it would help to solve the problem of marketing the milk after its arrival in the city. Some of the smaller concerns, including co-operative dairy societies, supplying milk to the city may be federated into a *dairy union*. This union could then be responsible for the marketing of the milk. It could also arrange for the establishment of several city milk depots with proper storage rooms, cooling appliances, delivery waggons, etc. The importance of the marketing of milk by responsible agencies cannot be overestimated, for unless the distribution of milk is taken away from the hands of the petty vendors and entrusted to a properly organised body, it would be extremely difficult, if not impossible, to stop the practice of adulterating milk with water. The public milk supply is more likely to be clean and pure if closely supervised in the manner described above, from its production to its final distribution, than under the present conditions. Moreover, the introduction of economic methods of dairying would tend to reduce the price of milk.

What is now required to make such agencies a complete success is proper supervision and some assistance from Government and the local Municipalities. The Government of Bombay have already announced their intention to help any Municipality if the latter laid before them any practical scheme to improve the milk supply.[1]

The assistance from Municipalities may consist in the provision of cattle stables and milking sheds near the city, the sanitary and legal control of the marketing of milk in the city by the provision of milk inspection, the establishment of milk depots, etc. Whether the milk is brought into the city by co-operative societies or private dairying firms—in any case—it should be made to conform to the required standards. If

1 *Journal of Dairying*, Vol. II, Part II, p. 103. *Vide* also G R. No. 7706 of 25-10-13 and G. R. No. 4644 of 18-7-14. General Department: Government of Bombay.

necessary, all imported milk may have to be rendered harmless by sterilisation, pasteurisation or any other means, at the distributing depots under Municipal supervision.

(D) Educational and other general measures.

"Education is one of the principal spokes in the wheel of the milk waggon."[1] —(*a*) *Education of the Public.*—Educating public opinion in the cities regarding the defects and dangers of the present milk supply and the urgent necessity for sanitary and other improvements is very important. Unless there is a definite and persistent demand for better milk, the supply will not be forthcoming. This can be done by spreading information broadcast by means of public lectures, sanitary tracts, practical demonstrations, publishing articles in the Anglo-vernacular press as to the best methods of collecting, storing, transporting and purveying milk, and the dangers to public health from the use of dirty milk, etc. The production of clean and wholesome milk is largely a matter of cost and education. The public must learn to appreciate the fact that clean and pure milk cannot be procured cheaply, and they must be willing to pay a reasonable price for it.

(*b*) *Instruction of the milk dealers regarding the economic and sanitary methods of supplying milk.*—This would be a very difficult task but not a hopeless one. Ignorance, apathy, and prejudice will have to be overcome, and sympathy, persuasion, and tact would have to be used in dealing with the Indian milkman. The instruction must be given free and adapted to suit local conditions. The committee on dairying at the Agricultural Conference at Coimbatore, in December 1913, recommended that provision should be made by Government for "free information and assistance to anyone willing to embark on a dairy enterprise of any sort. This should take the form of free plans and specifications for all classes of dairy buildings, free specifications and advice as to the purchase and erection of plant, advice as to correct systems of keeping dairying accounts and free information generally on all points connected with the establishment and working of dairy enterprise in any direction, so that anyone willing to invest money in the industry might be so guided as to ensure his organization being planned in the best possible manner for profit earning."

The city gowlee should be persuaded, if possible, to leave the city and settle in the suburbs, where he could produce milk under more economical and natural conditions.

[1] Rosenau.

The village cultivator should be induced to take up dairy farming along modern lines and he should be given free practical instructions in vernacular regarding the details of milk production, etc. He should be encouraged to rear the best breeds of cows and buffaloes, and the free services of a stud-bull at the nearest Government farm should be placed at his disposal. Practical demonstrations at a model dairy farm may be arranged from time to time for the benefit of village cultivators in the neighbourhood. There is also a great need for the establishment of dairy schools at suitable centres, where practical instruction in dairying could be imparted in simple vernacular. The gowlee as well as the agriculturist should be encouraged to send their children to such schools. Trained men would be also required by various dairying concerns, co-operative societies, etc., and the formation of special classes in the vernacular, where a short course of instruction in practical dairying and dairy farming could be given, would be very useful.

The staff of the Agricultural Department is not considered to be large enough for the needs of India, and it would not be fair to expect Government to do everything in the matter of imparting education to the agricultural population. There is a great opportunity for public-minded men, philanthropic bodies, wealthy Zamindars and Jahagirdars to organise missionary societies for the purpose of teaching and preaching to the village cultivator and the gowlee the gospel of economics, hygiene and sanitation. The Servants of India Society, the Social Service League of Bombay, the Bombay Sanitary Association and other similar organisations, might very well undertake this kind of work and thus supplement the efforts of Government.

(*c*) *The training of Milk Inspectors, etc.*—For this purpose a short course of instruction would be required in milk testing and general dairy sanitation, etc. Arrangements for giving such a course could be easily made in most of the cities in connection with the Public Health Department.

(*d*) *Provision for the training of Expert Dairymen and Dairy Farmers.*—An improvement in the dairy industry of India is possible, provided that there are a sufficient number of experts who have had a special training in modern dairying and dairy farming with some knowledge of chemistry, bacteriology, animal husbandry, economics, veterinary science and other kindred sciences.

As far as the author is aware, no suitable provision has been made by our universities and colleges for imparting such a special course. The Indian colleges of agriculture are, as a rule, separate from the Government dairies and from the veterinary department, and unless there is some co-operation between these, a complete educational course in dairying and dairy farming cannot be carried out. " Every colony in the (British) Empire has its Dairy Branch on the Agricultural Department except India, and no other country has the same possibilities of building up an industry of so great a magnitude and one that will so mightily improve all other branches of industry or give so much back to the State Treasury for any amount spent upon it.... India offers a field, for enterprising men who have a bent for this line of farming, second to none in the world, but those embarking in the trade must be possessed of a sound intelligence, industrious habits and a reliable training in the best methods introduced."[1]

It may be well for us to emulate the example of America, where dairying is taught as a part of the curriculum in many well-known Universities and where there is a large and well-equipped Department of Agriculture, which issues very useful Bulletins from time to time for the benefit of the dairy farmer. A large number of excellent dairy schools have been established in Great Britain during recent years. The Government dairies and a very few private dairies are the only places where a student could learn modern methods of dairying and dairy farming in India. These dairies might be well utilised in connection with our colleges of agriculture, and special graded courses could be offered for two or three years leading up to some certificate or diploma after passing the necessary examinations. Agricultural graduates with such special training would then be qualified for responsible positions, such as managers of dairies, etc.

An Indian branch of the Dairy Education Association has been established recently with headquarters at. Kirkee (near Poona.) A quarterly journal is issued by this Association in which various questions regarding dairying and dairy farming in India are discussed. The Association proposes to hold annual examinations in the science and practice of dairying in India. The successful candidates will be given the " National Diploma in the Science and Practice of Dairying in India." The subjects for the examination include practical agriculture, general dairying,

[1] "Journal of Dairying," Vol. I, Part 2 p. 39.

agricultural chemistry, bacteriology and general chemistry, veterinary science, dairy technology, etc.[1] This is the first systematic attempt to train dairymen in this country, and the Dairy Education Association deserves credit for taking the initiative in this important matter.

Dairy farming has a much more comprehensive meaning in India than in Europe. The duties of a dairy farmer in India are multifarious, and he must be familiar, not only with all branches of the dairy industry, but also with the allied subjects. The requirements and qualifications of a dairy farmer are well summed up in the *Journal of Dairying*, Vol. I, No. 1, (October 1913).

"A dairy farmer must be :—

1*st*.—A good business man, or he cannot make his farm a financial success.

2*nd*.—A keen observer, as his business is made up of innumerable details, which must be seen by him personally.

3*rd*.—A hard worker, as he must always be engaged in his work, for he is never finished; it therefore follows that his recreation must be found in his work.

4*th*.—A good breeder, as his success depends on his being able to get "two cows under one hide."

5*th*.—A student and investigator, the first as he must keep up his study to keep in touch with new methods; the second, as he must introduce new ideas to suit his particular environment.

6*th*.—Well trained in practice and theory, theory to guide him in a correct practical method.

7*th*.—Trained to absorb new methods, as these become necessary; and he must know the best grasses, crops, weeds, also all poisonous plants.

8*th*.—An intensive farmer, as he must use his manure and raise heavy crops continuously for green feeding on his own land.

9*th*.—The chemistry of feeding-stuffs, soils, manures, and dairy products should be studied to show him the cycle of application.

10*th*.—The elements of bacteriology taught, to show him the need of cleanliness, so that harmful bacteria shall not influence the quality of his produce and its keeping powers; and what pasteurisation and sterilisation mean.

11*th*.—A mechanical training is necessary to enable him to keep his machinery in order and prevent its failure; what

[1] The details will be found in the "Journal of Dairying," Vol. II, Part I. p. 51, etc.

machinery is necessary and which is the best for his purpose.

12*th.*—A knowledge of heat is required to enable him to know the principles on which his refrigerator works, and his cold store is kept cold.

13*th.*—A veterinarian, to enable him to keep his cattle in health and to treat them when sick."

The important points in connection with the economic, educational and other general measures may now be summed up :—

1. The scientific breeding of the " dual purpose " animal for India.

2. The establishment of cattle-breeding farms at suitable centres, and the supply of bulls on the premium system or otherwise.

3. Proper feeding according to physiological standards and based upon practical experience.

4. The removal of the city cattle-stables from the crowded areas to the non-residential parts of the city and to the adjoining suburbs.

5. Improvement in the tending of the cattle and better care of the progeny.

6. The provision for a large storage of fodder, both dry and in the form of ensilage.

7. Better irrigation, particularly in some of the districts in the Deccan.

8. The provision of suitable land by Government, on easy terms, for dairy-farming and grazing.

9. The organising or facilitating the export of valuable " dry " buffaloes and cows from Bombay, Calcutta and other large cities to suitable grazing districts, and taking other measures for the prevention of the slaughter of such animals.

10. The prevention of exporting the best breeds of Indian milch cattle to foreign countries.

11. The organisation of the city gowlees into co-operative dairy societies, the location of their animals outside the city, wherever practicable, and a gradual transformation of the gowlee into the village cultivator.

12. The erection, by the municipalities, of milch cattle stables and milking sheds (with the necessary provision for water supply and drainage) in the suburbs, which may be rented out to the gowlee and the cultivator at a concession rate.

13. The organisation of co-operative dairy societies of the village cultivators in the districts, which are within easy access of the city and where a large supply of cheap milk is available.

14. Improvement in the present methods of transport of milk, and better facilities for rapid and cheap transit.

15. The establishment of private dairying concerns on a large scale for the purpose of importing and distributing milk according to modern methods and under sanitary conditions.

16. The organisation of a "Dairy Union" in the city for marketing the milk brought in by the various co-operative societies.

17. The construction of milk depots, cold-storage rooms, etc., in the city.

18. The appointment by Government of dairy experts whose free services would be available to the above organisations.

19. Creating a demand for better milk by educating public opinion by means of lectures, demonstrations and the press.

20. Educating the gowlee and the agriculturist in modern methods of economic and sanitary milk-production.

21. The establishment of dairy schools and classes in the vernacular, etc., for imparting practical instruction in dairying and dairy farming and the training of milk inspectors.

22. Provision for the training of dairy managers and breeding experts in connection with the agricultural colleges and Government dairies.

23. The holding of milch cattle shows and the exhibition of milk products and dairy appliances in suitable centres from time to time.

II—SANITARY MEASURES, *including sanitary methods and reforms regarding the care and management of the milch cattle, their housing, the process of milking, the storage, transit and distribution, and artificial methods of preservation and purification of milk.*—These may be considered as follows:—1. Measures relating to the milch cattle, etc., to be applied by the producer at the source of the supply. 2. Reforms in the present methods of storage, transit and distribution of milk. 3. Precautions to be taken by the consumer. 4. Artificial methods of preservation and purification of milk:—(*a*) Refrigeration, etc., (*b*) Boiling, (*c*) Pasteurisation, and (*d*) Sterilisation by heat and electricity. 5. Infants' milk depôts. 6. "Certified" milk.

1. Measures relating to the milch cattle, etc., to be applied by the producer at the source of the supply.

(*A*) *Housing of the milch cattle.*—The essential requirements for a sanitary cattle stable are :—(*a*) *Location and size.*—It should be situated in a healthy spot either in the non-residential parts of the city, or better, outside the city within a convenient distance from it. It should be far away from the crowded districts, preferably in the small country towns and suburbs near the cities. The points in favour of this view have been already considered. The erection of small-sized stables should be given preference over a single large stable. The Bombay Municipal bye-laws allow a maximum of 100 animals per stable. The author is in favour of small stables with accommodation for not more than 50 animals per stable, placed " tail to tail " in two rows. A smaller number (20-25) would be even better. Some of the advantages of the smaller stables are : easier for control and supervision, better possibilities of ventilation, easier removal of manure, etc., less likelihood of excitement for the animals, and greater chances of proper feeding and tending the individual animal.

(*b*) *Provision for light, ventilation, air-space, etc.*—According to the model regulations of the Local Government Board, every dairy " shall be sufficiently lighted with windows, whether in the sides or roof thereof." There should be sufficient light to enable the whole interior of the stable to be easily visible in ordinary daylight. Savage[1] recommends a definite amount of light-space, namely, three square feet per cow. This should not be difficult in this country where there is plenty of bright sunshine. The animals should be placed in such a way that the light may strike them from the side or from the rear. Ventilation should be adequate and efficient. It should be so arranged as to prevent draught and to protect the animals from rain and wind during the monsoon, and at the same time to allow plenty of fresh air night and day. According to Schlossmann,[2] the air of the stable should not contain more than one part of carbonic acid to a thousand parts of air. A cow weighing 1,100 lbs. produces 12.71 cubic feet of carbonic acid which would have to be diluted one thousand times in order to maintain the requisite proportion (1:1,000). The introduction of the necessary

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[1] Wm. G. Savage. "Milk and the Public Health." 1912, p. 274.
[2] Schlossman. Wm. Ernst's *Milk Hygiene.*

air is made possible by three changes of air per hour, and according to Schlossmann, the air-space in a stable for cows weighing 1,100 lbs. each must be 176.5 cubic feet. Under Indian conditions, the air-space needed for buffaloes would be greater in proportion to their weight. A full-grown Jaffrabadi buffalo, for instance, is known to weigh as much as 1,800 lbs.

The model bye-laws of the Local Government Board recommend 800 cubic feet per cow. This would give about 50 square feet of floor space per cow. The Bombay Municipal bye-laws relating to milch cattle stables[1] require a floor-space not less than 12½ feet in length by 5 feet in breadth for each cow or buffalo. They further require an open space of not less than fifteen feet in width all around the stable.

(c) *Structural requirements.*—The construction of the floor, walls, drains, etc., should be such as to ensure thorough cleanliness. The composition of the *floor* is very important. It is essential that it should be of some impervious material, such as cement-concrete, so as to prevent the soakage of urine, wash-water, etc. The material used should be of the best quality, and in order to prevent slipping, the floor surface should be ribbed or made rough in some other way. It should slope gently (a gradient of 1 : 32, or ⅜" to the foot, is sufficient) back to a "grip" or manure channel, so as to facilitate ready cleansing. The so-called "Holland type" of stable floor consists of rather short standing space for the animals with broad, deep drainage trough in the rear into which the solid and liquid manure fall. The soiling of the animal is thereby prevented and the contamination of the bedding is reduced to a minimum. In Holland, it appears, that the tails of the animals are tied with a cord in such a manner that the tail hangs in a natural position while the animal is standing, but when the animal lies down, the tail is kept raised up so that it cannot be submerged into the contents of the drain! The *manure channel or gutter,* according to Speir,[2] should be 24 inches wide, 6 inches deep at the side next the cows and 4 inches at the walk. The *manure pit or dung receptacle* should be constructed of some impervious material, the bottom being raised above the surrounding ground. It should be situated at a reasonable distance (about 100 yards) from the stable and away from the water-supply. To prevent

[1] *Vide* Appendix D.
[2] Speir. *Public Health,* 1900 XII, p. 775.

the animals from backing into the manure channel or slipping in, a moulding of one-half inch may be provided along the upper border of the drain trough. The individual animals should be separated by means of partitions which extend upwards well over the shoulder and which are provided with fastenings for tying the animals (*vide* Plate XXXI). This is essential in order to prevent the soiling of the stalls with manure, etc. *The stall or manger* should be sufficiently long for the animals to lie down with ease, while it should be short enough to allow the manure to drop directly into the gutter. The exact length and width would vary with the size of the animal, and this would be different for different breeds of cows and buffaloes ; 5′-6″ by 4′-6″ for buffaloes, and 4′-6″ by 3′-6″ for cows are usually considered sufficient for each stall. The feeding troughs should be placed at the heads of the animals and so constructed that there would be no corners or crevices in which dirt may accumulate. They should correspond, as far as possible, to the conditions of natural feeding in the pasture. The troughs may be made of glazed stoneware[1] or cement concrete. A width of 1′-6″ is convenient. *The walls* of the stable should be covered on their internal surface, at least to a height of three feet, with some washable, impenetrable material, such as cement or white enamelled bricks. Some of the above details may appear to be trifling, but from a sanitary point of view they are of great importance.

(*d*) *Water-supply.*—This should be *pure, abundant and easily accessible.* It is required for drinking as well as for washing purposes. Where a public water-supply is available a pipe could be laid in the stable and a hose attachment would prove very useful for washing and flushing purposes. The provision of a separate paved washing-place for the animals is also necessary. It is very essential to have a pure water-supply in sufficient amount for cleanliness of the animals, the stables, the attendants, the milk utensils, etc. The water should be examined chemically and bacteriologically from time to time. As regards watering the animals, either each stall should be provided with an automatic water-supply or a long iron gutter running the whole length of the stable in front of the animals may be provided for, or separate water troughs may be constructed. The last seems to be the best way from a sanitary point of view.

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[1] Robertson and Porter. "Sanitary Law and Practice," 1912, p. 201.

The existence of insanitary cattle stables in the cities, particularly in the densely populated areas, is objectionable more from a public health point of view than on account of the animals themselves. They constitute a danger to the health of people living in the immediate vicinity. Besides, milk is very likely to get contaminated in such stables. When the stables, however, are located outside the city, elaborate sanitary arrangements are not necessary. Ordinary cattle sheds would serve the purpose very well. Under village conditions, so long as the animals are protected from extremes of weather and given plenty of fresh air, minute sanitary requirements are not essential. The principal reason for observing cleanliness in the stables is to protect the milk from contamination. All that is necessary for attaining this object is to have a central *milking-shed*, where the animals could be brought in for milking twice a day. Such a milking-shed should be constructed along sanitary lines and the utmost cleanliness observed during milking as described below. This arrangement would be more economical than the expensive city stables which have to conform to certain structural requirements. The animals are more likely to be comfortable in the ordinary country sheds than in the city stables with their hard and cold stone floors.

(*B*) *The process of milking.*—The process of milking in India, as stated already, is of a most primitive type and needs radical reforms. Milking may be compared to a surgical operation so far as antiseptic methods are concerned. The principles and methods involved in obtaining clean milk are practically the same as those employed in performing a clean operation. Scrupulous attention should be paid to minute details, and utmost cleanliness should be observed with regard to (*a*) the place at which milking is carried out, (*b*) the animals, (*c*) the person and clothing of the milker, and (*d*) the milk utensils.

(*a*) *The place at which milking is carried out.*—The usual custom is to milk the animals in the same place where they are tethered. For several reasons this is objectionable. The milk is less likely to be contaminated if milking is carried out in a separate shed or room specially constructed and used exclusively for that purpose. This may not be necessary where the stables are kept scrupulously clean. The structural requirements of a *milking-shed* would be similar to those mentioned for a sanitary cattle stable. According to the number of animals,

it may be necessary to have several milking-sheds. A circular or oblong structure is recommended with a central raised platform from which a responsible person could supervise the milking of the animals. The animals should be brought in batches of ten or twelve at a time in rotation. The milking-shed should provide accommodation for not more than twelve animals at a time, as only a small number of animals can be satisfactorily supervised at one time. The approaches to the milking-shed should be kept quite free from mud and manure. Plenty of hot and cold water should be ready on hand; a good boiler is indispensable. There should be ample provision for good artificial light, *e.g.*, large lanterns, "Kitson" lights, etc., as the "morning" milk is taken during the dark hours (2 a.m. to 4 a.m.) in Bombay.

(*b*) *Care of the animals.*—The animals must be free from disease This should be previously certified by the Veterinary Inspector. Each animal should be washed and cleaned thoroughly. It is not necessary—and in the case of cows it is not advisable—to wash the whole body of the animal just before milking. Particular attention should be given to the removal of all dirt from the lower and hind part of the abdomen, the udder, tail, groins, flanks and legs. The animals should be well brushed and combed at least half an hour before milking commences. The udders, teats and surrounding parts should be always washed immediately before milking. Any long hair on the udder, etc., should be clipped beforehand. Antiseptics may be used, but they must be entirely removed with sterile warm water so as to prevent their getting into the milk. After washing with clean warm water, the udders, etc., should be thoroughly wiped with a clean dry cloth which must be kept apart and used only for the udders. It may be objected that the above operation of washing and scrubbing would take up much time. Practical experience shows, however, that two men can wash ten animals in half an hour. It has been found that ordinarily not more than 12 buffaloes or 16 cows can be milked by one man in a satisfactory manner in about two hours. This gives an average of ten minutes per buffalo and about seven minutes per cow. A trained milk-man can manage to milk more animals than this.

(*c*) *The person and clothing, etc., of the milker.*—Only healthy persons should be allowed to milk the animals. Besides health, other essential qualifications for milkers are intelligence, clean-

liness, training and skill in milking. The hands and forearms should be washed each time a fresh animal has to be milked. Soap, water and nail-brush should be freely used. Disinfectants or antiseptic lotions are ordinarily unnecessary. Immediately before milking, the hands should be rinsed in sterile or boiled water and then wiped dry with a clean towel kept exclusively for that purpose. If a milking stool is used, it should be kept clean. After the hands have been cleaned, the milkman should touch only two objects: (1) the milking pail, and (2) the teats of the animal. The fingers must be kept away from the mouth and nose, and if the milker has to sneeze, cough, spit or perform any other similar operation, he must take good care not to let any of the spray get into the milk. All possible sources of contamination must be scrupulously avoided. The clothing of the milker must be always clean. It is advisable to put on a special "over-all" or long apron at the time of milking. This should be made of good washing material such as white "drill." When this is not practicable, a clean *dhotee* and *peharan* (a kind of shirt) should be worn just before commencing the milking. After the milking is over the special clothing should be removed and kept in a clean place.

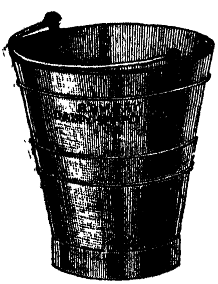

Fig. 1. Open pail.

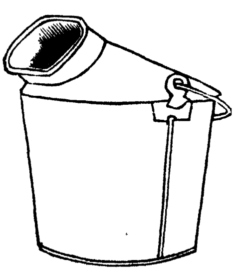

Fig. 2. Francisco pail.

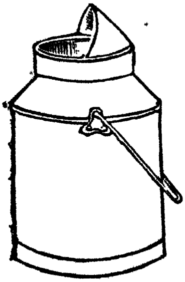

Fig. 3. Freeman pail.

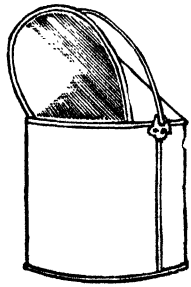

Fig. 4. Champion pail.

(*d*) *The milk utensils.*—The "milk pail" or collecting vessel used in India is generally made of brass and has a large wide mouth without any lid. This needs improvement both in the material used as well as in the shape. The milk pail should be so constructed that it would reduce to a minimum the amount of dust, dirt and hair which might fall into it during the process of milking. Figs. 1 to 4 show various types of pails.

The wide mouth pail or brass vessel is objectionable and should be replaced by a narrow mouth one. The opening at the top should be large enough to allow a thorough scrubbing and cleansing of the inner surface. The collecting vessels should have as few seams as possible; a seamless vessel would be best. All milk utensils should be heavily tinned, and where seams occur they should be flushed full and smoothed with solder. Galvanized iron, wood, or any material that is rough or porous should not be used for the construction of milk vessels[1]. One of the best milk pails used on the continent of Europe is the "*Algauer*" pail. This is a covered pail and is furnished with a receiving tube with a funnel at the upper end. Between the receiving tube and the funnel is an arrangement for straining the milk through clean cotton. Figures 5A and 5B show a milk pail specially constructed under the writer's directions.[2] The material used is either tinned steel or brass well tinned inside.

The "Sanitary" pail.

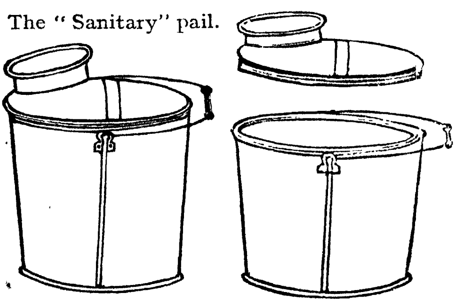

Fig 5A. (Closed.) Fig. 5B. (Open.)

(*c*) *The technique of milking.*—After the above-mentioned precautions and preliminary cleansing, the milk should be drawn in a quiet manner. Milking should never be done with wet hands or with a wet udder as this would make the filth from the fingers and the udder ooze out and drip into the milk pail. It is a common practice to wet the hands either with water or by milking a few streams over the fingers. This is very objectionable and should be absolutely forbidden. The hands of the milker as well as the teats of the animals must be kept *dry* while milking. The first three or four streams from each teat—the "fore-milk"—should be drawn into a separate vessel and discarded as it is likely to contain the largest number of bacteria. The milking must be done with thoroughness and at regular intervals. The amount of milk produced is largely

[1] Webster, E. H. "Sanitary Inspection and its bearing on Clean Milk," *Hyg. Lab: Bulletin*, No. 56, p. 562.

[2] A patent for this pail has been applied for.

affected by the thoroughness of the milking. Henkel[1] found that a cow yielded 17.8 lbs. of milk with 4.2 per cent. of fat when milked by a thorough milker, but only 12.3 lbs. with 2.7 per cent. of fat when milked by an untrained hand. As far as possible a regular twelve-hour interval between two successive milkings should be observed. The custom of first allowing the calf to suck its mother should be discarded as far as possible. When this is not practicable, then the udders, etc., must be again cleaned after the calf is withdrawn. It has been found unnecessary to allow the calf to have its milk directly from the mother. In the case of both cows and buffaloes it is advisable to remove the calf away from the mother and feed it by hand with the separated or skimmed milk obtained in the process of making butter. This would effect a great saving in the amount of good milk which would have been otherwise taken by the calf. All the sanitary precautions against sneezing, coughing, spitting, etc., should be scrupulously observed and every effort should be made to reduce to a minimum the chances of initial contamination. It is essential that the milkers should be specially trained for their work. The Indian milker, as a rule, does not use any milk stools or other seats, but squats on the ground as shown in Plate XXI. A milk stool would render the operation of milking more convenient and sanitary. It is immaterial what particular method is used in drawing the milk, that is, whether the teats are milked crosswise or the pair on one side or those of opposite quarters, simultaneously.

Milking-machines.—In recent years various forms of milking-machines have been devised as a substitute for hand-milking. These machines act by suction in imitation of the sucking of the calf. The suction is intermittent. The milk pail is connected by means of a rubber tube to the udder of the animal. The machines are used in many cities abroad, particularly in the United States. The main advantages claimed for these machines are, the rapidity of milking several animals at the same time, thoroughness in milking, and the prevention of possible infection from the milker. The working of milking-machines was carefully investigated by Woll and Humphrey.[2] They found no ill effects upon the cows, while their report is favourable regarding the economic efficiency of the machines. In samples

[1] Quoted by W. Ernst in his *Text Book of Milk Hygiene.*, p. 146.
[2] Woll and Humphrey. *Wisconsin University Agricultural Experimental Station*, 1909, *Research Bulletin No.* 3.

of milk drawn, by machines, they found the bacterial count slightly lower than in hand-drawn milk. The machines worked well only when kept absolutely clean and operated by intelligent and trained men. The author saw the working of several types of such machines in New York several years ago. The motive power used was electricity. Their construction is rather complicated and hence it is very difficult to keep them clean. They are also liable to annoying accidents. From an economic point of view the cost of these machines would be somewhat prohibitive as they would probably cost more than manual labour in this country. The use of milking-machines does not seem to be quite practicable for India, at least at the present stage of our milk industry, but they may be given a fair trial in some of the well-organised dairy farms. They have been tried at Kirkee at the Government Military Dairy and seem to work fairly with cows but not with buffaloes, owing to the peculiar structure of the udder and teats of the Indian buffalo. A few attempts made with buffaloes resulted in laceration of the fold of skin between the different teats. Perhaps a modified form of teat-cups to suit the anatomical requirements of the buffalo may be constructed.

(2) **Sanitary reforms in the present methods of storage, transit and distribution of milk.**—From the milk pail, or collecting vessel, the milk is usually distributed into other brass vessels of varying sizes. Straining or filtering of milk through "muslin" is practised by some milkmen. The kind of strainers generally used here are more likely to add dirt to the milk and increase the number of bacteria in it than to produce clean milk! If the process of milking has been carried out in a sanitary manner, straining would be unnecessary. Milk which is obtained in an insanitary way cannot be deprived of its objectionable quality by mechanical straining, for the filth dissolves and the bacteria pass through the straining cloth. Besides, straining the milk as a routine method might encourage the producer in his filthy habits and may serve as an excuse for being indifferent to clean methods of milking.

Cooling and Aeration.—As soon as possible after collection it is advisable to cool down the milk in a cooler or a refrigerator, which may be either in the milking-shed or in close proximity to it. The initial cooling and aeration are very valuable before putting it into milk cans for transit. The aeration

Fig. 6. The flat type of milk cooler.

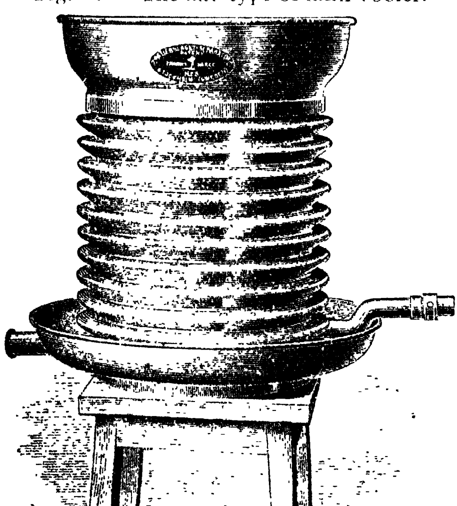

Fig 7. The cylindrical type of milk cooler.

permits the escape of any carbonic acid gas (CO_2), sulphide of hydrogen (H_2S), etc., and imparts to the milk an agreeable taste and odour. The cooling prevents the multiplication of bacteria. There are two types of milk-coolers, the flat and the cylindrical (Figs. 6 and 7). The milk is allowed to pass in thin layers on the outside of a coil of parallel pipes through which runs a stream of cold water or brine. The degree of coolness will be affected by (*a*) the rate at which the milk is allowed to flow, (*b*) the temperature of the cold water or brine, and (*c*) the extent of the surface exposed. It is important to remember that the cooler should be used in a clean place free from dust and with plenty of fresh air.

The transit of milk.—The vessels used for carrying milk from the producer to the purveyor or consumer, and the manner in which milk is at present transported, have been

already described. The brass milk vessels, or large *lotas* commonly used, need at least the following improvements :—(1) they should be thickly tinned internally ; (2) they should be provided with properly fitting covers and secure locks, etc. ; (3) they should have a large handle to facilitate handling ; (4) they should be washed and sterilised, or at least rinsed with boiling water just before use ; and (5) they should be air-tight. Some milkmen in Bombay have been recently using covers for their milk vessels, which are provided with holes for ventilation! According to W. G. Savage,[1] ventilation is unnecessary. He made comparative observations regarding the bacterial content, the rapidity of souring, etc., and found no constant differences. In America, the milk cans are usually covered with a closely-fitting metal lid. Eastwood in his report[2] on American methods remarks : " The fact that, in the American trade, milk is hauled in dustproof receptacles demonstrates the absurdity of the notion that ventilation holes are necessary." It would be better to use one-piece cans or churns made entirely of tin or steel than to trust the milkmen to satisfactorily tin their brass lotas. Milk cans (or churns) to hold one maund and half a maund respectively, (80 lbs. and 40 lbs.), would be convenient sizes for transit. The milk cans or churns should be securely locked or sealed so as to prevent any tampering on the way. They should have no joints or seams, but should be in *one piece*[3] (Fig. 8) After arriving in the city, the milk would have to be distributed to the retailer and this might be a fresh source of contamination. The most sanitary and ideal way would be to put up the cooled milk into bottles of varying sizes at the source of the supply and sell it in the original bottles, provided that they are thoroughly cleaned and sealed. The question of using milk bottles in India has been discussed by H. J. Riddick in the *Journal of Dairying in India* (Vol. I,

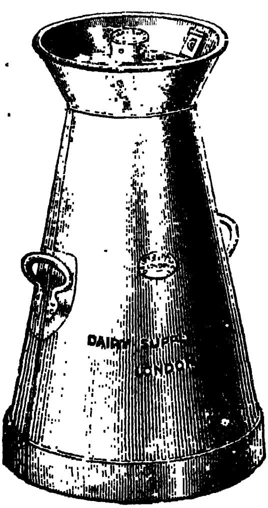

Fig. 8. One-piece Churn.

[1] Savage. " Milk and the Public Health " 1912, p. 290.
[2] Eastwood, *Report to the Local Government Board*, 1909, *New series*. No. 1, p. 76.
[3] Such cans are supplied by the Dairy Supply Company of London, at their Bombay depot.

No. 4). After pointing out the defects of the " Hygeia " and other bottles, he recommends the use of (1) a glass bottle to be sealed by means of a specially prepared waterproof cap, or (2) the " Bourne bottle " with its patent closing cap. Both these bottles have wide mouths. In (1) the waterproof cap is secured fast around the neck of the bottle by a metal band, which has several kinks or dents in it. This band has to be forced down in order to open the bottle. It cannot be again forced up without being broken at one of the kinks and any attempt to open the bottle in transit could be easily detected. The caps are in the closing machine in sterile packets; hence there is no objectionable handling. (2) The " Bourne milk-bottle " is sealed by means of a patent lever stopper. By pressing down the lever the bottle is closed automatically and an adhesive label is now fixed over the cap. To open the bottle, it would be necessary to break the label in order to raise the lever. The main points against the use of the glass milk-bottle for India are (1) its initial cost, (2) likelihood of breakage, (3) more expensive rates for conveyance, (4) its weight, (5) the difficulty of cleaning it thoroughly, for thousands of bottles would be needed for the city supply, and (6) it is not likely to be popular with the Indian public. Glass milk-bottles have been used in India by a few large dairies where it is possible to make the necessary arrangements for cleansing and sealing the bottles. For large concerns, it may be necessary to have bottle-washing machines as used in America. On the whole, it appears, however, that milk-bottles to be filled at the source of the supply and then conveyed in railway trains, etc., to the city, are not suitable for Indian conditions; but at the distributing depot in the city, milk may be put up in bottles only for those customers requiring it. The average native of India would rather have milk in metallic vessels than in glass bottles. Even in advanced cities like Bombay, the great majority of Hindus as well as Mahomedans would prefer a brass or aluminium vessel to a glass bottle. Aluminium vessels, or better, tinned steel (*one-piece*) of varying capacity with wide mouths and secure arrangement for sealing would answer the purpose very well.

The distribution of milk.—If the business of importing and purveying milk were in the hands of a few large concerns as suggested above, it would be much easier to exercise sanitary control over the distribution of milk than otherwise. The milk

depots and milk-shops in the city should be under strict sanitary supervision and legislative control. Clean methods must be used in every detail of distribution in the same manner as during collection and transit. The methods of conveying milk in small bulk for house to house delivery require considerable improvement. The insanitary methods (*vide* Plates XXII and XXIII) must be replaced by modern modes of delivery such as milk-barrows, milk carts, the "carrier tricycles," etc. The milk-vendor should be instructed to keep his fingers away from the milk, while measuring it out from the container, by the use of measuring vessels provided with a handle.

(3) **Precautions to be taken by the consumer.**—The average consumer in this country is almost as careless and indifferent as the producer, regarding clean methods of keeping milk in the household. Among the well-to-do classes the care of milk is usually left to the ignorant and often dishonest servants. The consumer must see that a responsible member of the household personally attends to all the details. The vessel used for keeping milk is usually a metallic one. If it is of brass, care must be taken to have it tinned frequently, and thoroughly cleansed. Just before taking the milk, the vessel should be rinsed with sterile or boiled water. It should then be covered with a suitable cover and kept as cool as possible. If this is not practicable, then the milk should be boiled. *Boiling all milk* has been the custom in nearly every Indian household for centuries, and considering the numerous chances of contamination of milk in this country, this is a very efficient protective measure, provided that the milk is really brought to the *boiling point.* Every precaution should be taken, however, to guard against re-contamination. The nutritive value of boiled milk as compared with raw milk has been fully discussed in the latter part of Chapter VI. Should the consumer suspect that the milk supplied to him is adulterated with water or contaminated with manure or other dirt, he should immediately arrange to have a sample taken by the Public Health Department of the city for laboratory examination. Persons who desire to use raw milk must arrange to have a proper ice-box and the milk vessel must be kept in contact with the ice so as to be constantly at a low temperature, always *below* 50°*F.* The upkeep of an ice-box is rather expensive here, and only those who can afford to pay the high price of ice in Indian cities could maintain an ice-

box. The precautions to be taken by the consumer mainly consist in *cleanliness and boiling or cooling* below 50°F.

(4) **Artificial methods for the preservation and purification of milk.**—Most people would prefer to have *pure* milk rather than *purified* milk. The methods described below cannot atone for filth, with which the public milk-supply in Indian cities is generally contaminated. It has been stated in Chapter II that the main factors responsible for the rapid multiplication of bacteria in milk are the initial contamination, time and temperature. The initial contamination can be avoided by taking sanitary precautions as already described. It is a well-known fact that milk will not keep fresh very long, particularly in a hot country like India. This has been shown to be due to the rapid multiplication of bacteria under very favourable conditions of temperature, etc. Under modern conditions of city life, considerable delay is inevitable between the production of milk and its delivery. The greater the delay, the greater is the number of bacteria in it, unless the milk is kept at a low temperature; in other words, the milk must be cooled down and maintained at a low temperature if we desire to keep it fresh as long as possible. Another method of preserving milk is by the addition of certain chemical substances, but as this is considered to be objectionable, it is not recommended. Pure milk produced under the best sanitary conditions, and kept clean until its consumption, would be the ideal, and nothing short of this should be aimed at. But it must be remembered that, even with the most exacting care, milk is sometimes apt to become infected with dangerous bacteria, such as those conveying Cholera and Typhoid fever, by means of "carriers," flies, etc. Besides, so long as the average market milk in Indian cities shows such high contamination as demonstrated in Chapter IV, the only protective measure to be adopted is to kill the objectionable microbes by means of pasteurisation, sterilisation or boiling. Any method for preserving and purifying milk should be carefully selected after considering its advantages and disadvantages from the economic, sanitary, and public health points of view. The following methods will be briefly considered :—(*a*) Refrigeration, (*b*) Boiling, (*c*) Pasteurisation, and (*d*) Sterilisation by Heat or Electricity.

(*a*) *Refrigeration.*—This is the best method for preserving clean milk for a considerable time; the milk retains its freshness and "sweet" taste. It is used extensively in the United

States, England and other cold countries. The milk is cooled immediately after drawing and kept at a low temperature (35° to 50°F.) continuously until it is delivered to the consumer, who continues to maintain the low temperature by keeping it in an ice-box. Cooling the milk even to the freezing point does not kill or injure in any way the bacteria present nor does it diminish the harmfulness of the pathogenic microbes that may be present; but it prevents their further multiplication. Savage[1] found that in milk samples kept at 0°C to 10°C no marked increase of bacteria took place within twenty-four hours. There is a difference in growth of the various kinds of bacteria at different temperatures, *e.g.*, the lactic acid bacteria multiply rapidly at 20°C, while at 37°C. B. Coli communis and B. lactis aerogenes grow vigorously. A few species of microbes appear to be well adapted to a low temperature (1°C to 10°C).

Milk is not necessarily wholesome or safe from a bacterial point just because it has been kept at a low temperature. It would depend on the initial number and kind of bacteria present. The writer had occasion to examine 118 samples of milk from a well-known dairy in Bombay, which were reported to be kept at a temperature ranging from 41°F to 50°F. This temperature was maintained until examination of the milk at the laboratory. The average total count was found to be thirteen millions of microbes per c.c., and lactose fermenters were present in a dilution of 1 : 100,000. Refrigeration is an efficient method for the preservation of milk, as the low temperature prevents the multiplication of most bacteria, but it cannot destroy the injurious bacteria nor can it atone for the filth.

The main objection to the use of this method in India is its high cost. The cost will depend a great deal upon the price of ice which is rather high in most Indian cities. In some of the smaller cities there are hardly any facilities for obtaining a sufficient amount of ice. Ice being cheap in Europe and particularly so in America, and the climate being cold, it is not expensive there to maintain a temperature below 50°F. Here, in India, with costly ice and a high atmospheric temperature, refrigeration of milk would be an expensive process. The ordinary milk dealer could never afford to use it. The only way by which it may be practicable to use refrigeration in this country is through the formation of large dairying concerns, which would be

1 William G. Savage. *Milk and the Public Health.*

able to handle very large amounts of milk. In place of ice, brine may be employed in connection with a refrigerator. If it be desirable to keep the milk cool from the very beginning, as in certain cases of infant feeding, recourse may be had to a special milking-pail which is provided with a cooling arrangement. A cheaper method for prolonging the life of the milk to some extent would be water-cooling and mechanical cleaning.

(*b*) *Boiling.*—The effects of boiling on the chemical composition and bacterial content of milk have been already considered in the previous chapters. The question of boiled milk for children and its nutritive value, etc., have been discussed at length in Chapter VI. It was shown conclusively that *boiled milk is not inferior to raw milk as regards its digestibility and nutritive properties.* Ample clinical evidence was quoted to show that according to most observers, the use of boiled milk has not been found to be detrimental to infants, either as regards nutrition or the development of diseases like rickets, infantile scurvy, etc. From a consideration of the thermal death-points of bacteria, it is evident that boiling destroys almost all the pathogenic microbes excepting the spore-bearing bacteria. Boiling is therefore considered to be one of the most efficient methods for the purification of milk, and can be recommended as the safest and cheapest method for domestic use. The effect of boiling milk on the bacteria present was studied by the author. It was found that boiling for a moment kills almost all the bacteria, pathogenic as well as non-pathogenic. The milk was boiled in an ordinary vessel and afterwards allowed to cool down, the vessel being properly covered. The manner in which milk is usually boiled in Indian households was imitated as far as possible. No unusual precautions were taken except that scrupulous cleanliness was observed in handling the milk. Ten samples of genuine buffalo milk were examined bacteriologically before and after boiling with the following results :—

TABLE showing the difference between Raw and Boiled Milk.

No. of samples.	Raw Milk, and Boiled Milk Immdt. Examd.	Microbes per c.c.	Lactose Fermenters.	B. Coli	Remarks.
1	Raw	10,800,000	+ in .00001 c.c.	+	
	Boiled.. ..	86	—	—	After 1 hour=217; after 3 hours=628 (Microbes per c.c.)
2	Raw .. .	8,386,000	+ ,, .0001 c.c.	+	
	Boiled.. ..	10	—	—	
3	Raw .. .	11,842,000	+ ,, .00001 c.c.	+	
	Boiled.. .	34	—	—	After 1 hour= 51; after 2 hours=324 (Microbes per c.c.)
4	Raw	9,843,000	+ ,, .0001 c.c.	—	
	Boiled.. ..	47	—	—	
5	Raw .. .	12 438,000	+ ,, .0001 c.c.	+	
	Boiled.. .	Sterile.	—	—	After 1 hour= 84; after 3 hours=134 (Microbes per c.c.)
6	Raw .. .	10,450,000	+ ,, .0001 c.c.	—	
	Boiled.. .	Sterile.	—	—	After 3 hours=84.
7	Raw .. .	13,148,000	+ ,, .0001 c.c.	—	
	Boiled.. ..	58	—	—	
8	Raw .. .	14,387,000	+ ,, .0001 c.c.	—	
	Boiled.. ..	31	—	—	
9	Raw	11,894,000	+ ,, .001 c.c.	—	Was boiled in a **sterile** test **tube** and **kept** at **room temperature** :—***Remained sterile for 24 hours.***
	Boiled.. ..	27	—	—	
10	Raw .. .	8,314,000	+ ,, .001 c. c.	—	
	Boiled.. ..	Sterile.	—	—	

+ = Present; — = Absent.

(c) *Pasteurisation.*—Soon after the Franco-Prussian War *Pasteur* found that beer could be preserved by heating it to a temperature of 50° to 55°C for a few minutes. In 1886, *Soxhlet* suggested the heating of milk for infant feeding. By pasteurisation is meant the heating of milk for a short time to a temperature below that of boiling, to be followed by rapid cooling. Pasteurisation destroys only some of the bacteria in milk, and pasteurised milk is liable to be "spoilt" in the same way as raw milk. It must be remembered that pasteurisation is not merely heating below the boiling point, but the subsequent rapid chilling is very essential. The temperature and time of exposure for pasteurisation vary a great deal according to different observers. The temperatures recommended range from 60° to 70°C (140° to 158°F), and the time from three minutes to thirty minutes. According to Danish Law, a temperature of 80°C (176°F) is required.

There are two principal methods of pasteurisation:—(1) the "*flash*" method, and (2) the "*holding*" method. In the *flash* or *continuous flow* pasteuriser, the milk is heated to a somewhat high temperature (70° to 80°C) for a moment and then suddenly cooled. The results obtained by this method are generally unreliable and it cannot be depended upon to kill all the pathogenic microbes, *e.g.*, the *tubercle bacillus*. In the *holder* or *retainer* type of pasteuriser, the milk is heated at a lower temperature (60° to 65°C) for a prolonged period (20—30 minutes) and then cooled immediately. This method is sometimes called *perfect* pasteurisation; it gives very satisfactory results and is therefore preferable to the flash method. Various patterns of pasteurisers of the retainer type are now in the market. A third way of pasteurising milk is *pasteurisation in the final container* or in *the milk bottle*. This is, no doubt, the most efficient way as it eliminates the possibility of re-infection. The milk bottles are corked and sealed, and then immersed in a water-bath. The water-bath is heated until the temperature of the milk within the bottles is 148°F. This temperature is maintained for 30 minutes. The bottles are then cooled by placing them on ice. This method, with some modification, may be adopted for *home* or *domestic pasteurisation*. A very practical home-pasteuriser is that devised by *Freeman*. A modified form of this is the Straus pasteuriser devised by *Nathan Straus*, who has been an early and prominent advocate of the pasteurisation of

milk and whose philanthropy has helped the establishment of infants' milk depots in New York. "Pasteurisers must be efficient in operation, permitting a definite quantity of milk to be heated to a definite temperature for a definite time (Russell). They must be easy to control, and the milk must be heated uniformly throughout, the apparatus must be simple in construction, easily cleaned, economical in use, and arranged to safeguard against re-infection of the milk. Further, an efficient pasteuriser must not heat any part of the milk appreciably higher than the temperature desired. Finally, provision must be made for rapid cooling."[1] A large amount of scientific work in connection with pasteurisation of milk has been carried out in America, notably by Ayers, Johnson, Rosenau and others. Ayers and Johnson[2, 3] made a special study of the bacteria which survive pasteurisation. The average temperature used throughout the United States with the "holder" process is 62.8°C (145°F) and with the "flash" process it is 71.1°C (160° F)[3]. According to these observers, a percentage of bacterial reduction is of no value in determining the efficiency of the process of pasteurisation. They mention four distinct groups of bacteria that survive pasteurisation, namely, the acid-forming, the alkali-forming, the inert and the peptonizing. The percentage of the acid group is increased by pasteurisation while the other groups are decreased. Experiments carried on by the author in Bombay (*vide* Chapter V) show that the number of bacteria is decreased considerably by pasteurisation. Besides, in pasteurised milk, B.Coli communis, B.Enteritides Sporogenes were always absent, while in raw market milk in Bombay B.Coli was detected in about 95 per cent. of all samples examined. The gas-forming organisms, however, survive pasteurisation.

The main known facts about pasteurisation of milk may be now stated as follows :—

1. Pasteurisation, when efficiently carried out, destroys most of the harmful organisms. It thus prevents disease and saves lives.

2. While pasteurisation destroys most of the bacteria present, there does not seem to be any positive evidence as to whether it destroys their *toxins* or otherwise.

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[1] *Rosenau.* "The Milk Question," p. 213.

[2] S. Henry Ayers and William T. Johnson. U. S Dept. of Agric. Bur. Anim. Indus. Bulletin No. 126.

[3] S. Henry Ayers and William T. Johnson. U.S. Dept. of Agric. Bur. Anim. Indus. Bulletin No. 161.

3. Pasteurised milk is just as digestible and nutritious as raw milk (Rosenau).

4. The best temperature for pasteurisation of milk is 140° to 145°F (60 to 62·8°C), and the time of exposure should be from twenty to thirty minutes. The cooling should follow imme diately and the milk kept at 40° to 50°F.

5. Pasteurisation renders milk comparatively harmless, but it is not an ideal process as it cannot atone for filth. It is useful, however, as a temporary expedient.

6. One of the main objections to pasteurisation is that it is likely to promote carelessness and encourage dirty customs and habits.

7. Pasteurised milk is liable to re-infection, hence the false sense of security should be guarded against.

8. Pasteurisation cannot make good milk out of bad milk. If pasteurisation is to be adopted, then only such milk as would comply to some reasonable chemical and bacteriological standards, should be allowed to be pasteurised.

9. Pasteurisation in order to be efficient must be carried out under rigid supervision.

10. The cost of pasteurisation is comparatively moderate, and from an economic standpoint pasteurisation has been found to be practicable only for large concerns which handle very large quantities of milk.[1]

(*d*) *Sterilisation by Heat, Electricity, etc.*

(i) *Sterilisation by Heat* is a step further than boiling and consists in heating the milk to a very high temperature, usually at about 120°C (248°F) for fifteen to twenty minutes. This results in the destruction of all microscopic life. Milk thus treated and protected from re-contamination will keep indefinitely. Samples of ordinary market milk obtained in Bombay were sterilised by the author at a temperature of 120°C for 15 minutes and kept in glass-stoppered sterile bottles; after twelve months they were still found to be sterile and in good condition. Sterilisation by heat brings about profound physical and chemical changes in the milk as shown in previous chapters and for this reason this method has not found much favour either in England or in America. The "sterilised milk" sold in Europe is not always *sterile*. Savage[2] found only 51 per cent. samples of "steri-

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[1] According to Mr. G. H. Frost, the smallest amount of milk that it would pay to collect and pasteurise at one depot in India would be 2,000 lbs. per day. Vide also Appendix A.

[2] Savage. "Milk and the Public Health," p. 374.

lised milk" to be sterile. Robertson and Mair[1] examined milk sterilised in bottles in an infant milk depot in England, and found that only 15 per cent. were sterile. Weber[2] of Berlin examined 150 samples of "sterilised milk" and found 54 per cent. to be sterile. These observations show that the "sterilised milk" of commerce is generally unreliable.

One of the principal effects of sterilisation on milk is the precipitation of the calcium and magnesium salts. The calcium salts in milk are considered to be essential for the curdling of rennet in the process of digestion. According to some authorities,[3] children fed on sterilised milk are likely to suffer from scurvy and rickets. Other observers,[4] on the other hand, maintain that sterilised milk does not seriously interfere with digestion nor nutrition, and scurvy is extremely rare or absent among children fed on such milk. Many of these observations have been discussed in Chapter VI. Some observers do not mention the temperature at which the sterilisation was carried out. This is, however, very important for comparing results. Besides, very little is known regarding the essential nature of scurvy. Kœppen and Rosenau's views relating to this question have been already quoted in Chapter VI. There is a great divergence of opinion regarding the use of "sterilised milk" for children, and it will be seen from the above references that well-known observers have come to diametrically opposite conclusions. The majority of observers are able to cite clinical evidence to the effect that a large number of children in several places have been fed on sterilised milk without any apparent prejudicial effect. Considered from chemical and physiological points of view, it appears that milk heated at a low or moderately high temperature for a moment is more desirable than milk subjected to prolonged heating at a very high temperature. Sterilisation

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1 Robertson, and Mair. "British Medical Journal" 1904, Vol. I, p. 1122.

2 Weber. "Arbeit. a. d. Kaiserl. Gesundheitsamte," 1900 Vol. XVII, (quoted by Savage).

3 1 William Ernst. "Text Book of Milk Hygiene," p. 194.
2 Robert Mond. "Dangers of sterilised milk," quoted in the Journal of Dairying in India, Vol. I, No. 3, p. 260, etc.

1 Finkelstein. "Therap. Monatsh," Vol. XXI, Oct. 1907, p. 508.
2 Variot, M. G. "Valeur nutritive du lait de vache sterilise a 108° pour l'allaitement artificiel" *Comp. rend des Seances de l'Academ. d. Sci.*, Vol. 139, 1904, p. 1002. (quoted by Rosenau.)
3 Savage. "Milk and the Public Health," p. 377.
4 Rummell, O. "Sterilisierte Milch?" *Deut. Praxis*, Vol. 13. (quoted by Rosenau 1904, pp. 201-207.
5 *Park and Holt*: "Report upon the Results with Different kinds of Pure and Impure Milk in Infant Feeding in Tenement Houses and Institutions of New York City: A Clinical and Bacteriological Study." *Archiv. Pediat, Dec.* 1913.

of milk has been recently advocated in India. It is stated that the cost of sterilisation, including bottling, is much higher than that of pasteurisation. Further practical observations and experiments are, however, necessary. Apart from the cost, it is not likely to be very popular on account of its peculiar taste. Besides, when it is homogenised it would not be suitable for preparing butter.

(ii) *Sterilisation by Electricity.*—The sterilisation of milk through alternating electric currents of high tension was first recommended by Guarini and Samarini.[1] They did not, however, work out any practical methods for carrying out their suggestion. It was only recently that Novey and Caldwell[2] of the Ohio State University (U.S.A.) succeeded in sterilising milk by means of electricity. This has been followed in England by Beattie and Lewis[3] at the University of Liverpool. In the American method, the milk is allowed to flow through a series of metal vessels which form the electrodes, while an alternating current of 2½ ampéres with a voltage of 2,000 is applied for fifteen seconds. This has been found to result in the reduction of the bacteria present to the extent of 99.97 per cent. *Chemically, there was no change in the composition of such milk.* In Liverpool, many experiments have been made by Prof. Beattie and Mr. Lewis. A suitable apparatus has been constructed by the latter, and milk has been sterilised on a large scale. A rapidly alternating current is used. The results obtained may be summarised as follows[4]:—

(1) The total number of bacteria is greatly reduced by about 99.93 per cent.

(2) Bacillus Coli and its allies are destroyed.

(3) Tubercle bacilli are destroyed. This has been verified by inoculating guinea-pigs.

(4) No chemical change in the milk can be detected.

(5) The taste and odour of the milk are quite unaltered, while its keeping power is greatly increased.

[1] Guarini and Samarini, quoted by Wm. Ernst in his "Text-book of Milk Hygiene" 1914, p. 202.
[2] Novey and Caldwell—quoted in the "Jour. of Dairying," Vol. I, Part 2.
[3] Beattie and Lewis. "British Medical Journal," April 4th and June 20th, 1914.
[4] Quoted by the "British Food Journal," March 1915, p. 44.

Further investigation is being carried out at Liverpool with a view of perfecting the method and applying it on a commercial scale to the public milk supply. As no chemical changes have been found to occur in the milk, it is presumed that its digestive and nutritive properties are equal to those of raw milk. Should this method prove to be successful from the scientific, clinical, as well as economic points of view, then it would be the best and safest method for purifying and preserving milk. Most of the large cities in India are provided with electric power which could be utilised for this purpose. As regards Bombay, advantage could be taken of the new Hydro-Electric Works of Messrs. Tata & Co., from which it might be possible to obtain cheap and sufficient electric power for sterilising part of the milk supply of Bombay.

(iii) *Sterilisation by means of Ultra-violet Rays.*—The bactericidal action of ultra-violet rays has been utilised for the sterilisation of milk by Seiffert.[1] According to Lobeck,[1] the exposure of water to such rays results in the production of hydrogen peroxide, and to this may be ascribed the bactericidal power of ultra-violet rays. There is no change in the milk fat. Several observers have obtained favourable results with the ultra-violet rays from mercury and quartz lamps. Mohler and Eichhorn[2] commenting on the results obtained by Ayers and Johnson, express a doubt regarding the use of ultra-violet rays on a commercial scale so as to replace the process of pasteurisation.

On the other hand, the Dairy Supply Company of London has been advocating the use of Walkey's Patent Ultra-violet Ray Steriliser. The apparatus consists of a chamber having four sides. The milk is admitted at the top from a suitable distributing vessel, and flows in a thin stream over the corrugated surface on each side in the interior of the chamber. In the centre of the space are three mercury vapour lamps with quartz tubes, arranged to give a maximum effect of intense light. The lamps are worked by direct electric current. The electricity required is about two units per hour. The total expense of running a 200-gallon apparatus is given at 3*d.* per hour. It is claimed that milk treated by ultra-violet rays suffers no loss in volume nor is there any alteration in its chemical

1 William Ernst's *Text Book of Milk Hygiene.*
2 *Ibid,* page 201.

contents, but is rendered quite sterile. The comparative cost and results are given as follows :—

Heat pasteurisation	*Sterilisation by ultra-violet rays.*
1. Cream does not rise after.	
2. Loss of about one quart of milk on each churn pasteurised.	1. Cream rises as with fresh milk.
	2. No loss.
3. Costs 4*d*., each churn pasteurised.	3. Costs one-fifth of penny each churn.
4. Taste noticeable.	4. No taste of sterilisation.
5. Milk pasteurised at 168°F. and cooled immediately ; two-thirds original bacteria destroyed.	5. Milk sterilised by Ultra-Violet Rays ; all bacteria destroyed and milk sterile.
6. Raises the temperature to at least 168°F, requiring expensive cooling to reduce it again.	6. Raises the temperature by only 30°F.

It appears that milk can be sterilised in six seconds by Walkey's Patent Ultra-violet Ray Steriliser.

None of the above methods of purifying milk could be said, however, to solve the milk problem. They are very useful and should be tried until an adequate supply of pure fresh milk would be available. Our chief aim should be to so improve the present methods of handling milk as to ensure a fresh supply of clean and pure milk rather than obtain milk which has been artificially purified. Considered from the economic, sanitary and physiological points of view, the choice of the quality of milk for consumption in the order of merit appears to be as follows :—

A. For adults and children :—

1. *Clean and wholesome fresh milk,* free from adulteration and any injurious bacteria, conforming to the chemical and bacteriological standards, and obtained from healthy animals. *This is the ideal.*

2. *Boiled milk,* thoroughly boiled at home and guarded against re-contamination.

3. Milk that has been *sterilised by electricity.*

4. *Pasteurised milk* that has been kept cool (under 50 °F) and guarded against re-contamination.

5. *Milk sterilised by heat.*

B. *For children under one year of age :—*

(1) *Mothers' milk.—Breast-feeding is the best for infants* (under 12 months), and nothing can ever take the place of human milk.

(2) *Fresh cows' milk* (modified) which has been obtained with the most careful sanitary precautions and kept at a low temperature (below 50 °F). It must be "certified" as to its chemical and bacterial contents, etc.

(3) Milk *sterilised by electricity* and modified to suit the individual requirements of the child.

(4) *Pasteurised milk* kept at a low temperature (below 50 °F).

(5) *Boiled milk* (after modifying it), to be given only if 1 to 4 are not available.

All milk, other than human milk, must be suitably modified according to the physiological requirements of the individual child and made to approach human milk as far as possible. General formulæ are often misleading. Each case must be studied by itself and a suitable modification of milk should be determined by the physician. The following principles for modifying milk for children may serve as a guide :—

(1) *Removal of some of the fat.*—This is important, as the milk from Indian cows and buffaloes contains a very high amount of fat.[1]

(2) *Sterilising* (*electric*), *pasteurising*, or *boiling*, if necessary.

(3) *Dilution* with sterile water. The amount to be added will vary according to the casein content, etc., of the milk, age of the child, etc.

(4) *Sweetening* with lactose or other sugars.

(5) *Addition of lime-water barley-water, etc.*, according to the physician's prescription.

5. Infants' Milk Depots.

Milk depots for the supply of pure or purified milk for children are of comparatively recent origin. The first milk depots were established in 1889, in Hamburg[2] and in New York.[3] In

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[1] According to Major L. T. Rose-Hutchinson, I.M.S., (Professor of Physiology, Grant Medical College, Bombay) the percentage of fat should not exceed 3.5 for infants in India.

[2] Von Ohlen, Milk Depots in Germany. *Public Health*, 1905.

[3] *New York Medical Journal*, Jan 31, 1891 and Febr. 4, 1893

1892, the first French milk depot was opened in Paris by Variot in connection with the Belleville Dispensary. The first British milk depot for infants was established in 1899. Since then several depots have been opened in Liverpool, London, etc.

The depots in England are usually financed and controlled by the Municipalities. At these depots milk is modified chemically by using various proportions of milk, cream, sugar and water, according to physiological requirements. It is purified by pasteurisation or sterilisation. It is then distributed in sealed bottles and sold to the poor at a low price, the deficit being made up by the Municipality. The milk is supplied only in suitable cases; the homes of the children are visited by the health visitor, and the children are weighed from time to time.

It appears that in Liverpool the rate of infant mortality has fallen considerably since the establishment of infants' milk depots. This may not be entirely ascribed to the better milk supply, but also to the additional care bestowed upon the infants and to the advice given by the health visitors, etc.

In the United States, in the year 1907, infants' milk depots were in operation in twenty-two different cities.[1] The majority of these owe their existence to private philanthropy and are not maintained at public expense. In addition to the care exercised at the depots, the milk is put up in a manner to prevent contamination in the home. Each bottle contains only one feeding and is so designed that it will not stand on end, and therefore cannot be left standing open. All the depots are under medical supervision, and the milk is modified according to requirements. These depots have been beneficial in reducing infant mortality in American cities,[1] although it is difficult to demonstrate this by means of statistics.

Infants' milk depots may be given a trial in our cities, although they should never be a substitute for breast-feeding. They would be useful in supplying pure and modified milk to children at a low cost when breast-feeding is impossible. Private philanthropy, financial support from the Municipalities, as well as co-operation of the medical profession would be necessary for the establishment of such depots. Rigid sanitary supervision would be, of course, essential, both at the source of the supply as well as at the distributing depots.

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[1] Hygienic Laboratory Bulletin No. 56, p. 632. Washington, D.C., U.S.A.

(6) **"Certified Milk."**—This term was first used by Dr. Henry L. Coit[1] of Newark, N.J., U.S.A., who in 1892 outlined his scheme for producing genuine and clean milk under the supervision of the Medical Milk Commissions. The first Medical Milk Commission in America was organised in 1893 in Essex County in the State of New Jersey. According to Dr. Coit,[1] "the plan provides that the Medical Commission establish correct clinical standards of purity for the milk; become responsible for periodical expert inspections of the dairy or dairies under its patronage; provide for frequent examinations of the product by a chemist and a bacteriologist, the first to determine its food values, and the latter to serve as a detective control over the methods employed in collecting and handling the milk. The Medical Commission also directs a frequent scrutiny of the live stock by competent veterinarians, whose duties consist in keeping the herd free from disease and also in the detection and exclusion of bovine tuberculosis. Likewise the Commission directs a systematic medical supervision of the health of the dairy employees, and insists upon a continuous knowledge, through reports by a physician, of their health and personal hygiene. By the service of reliable experts in these four departments, safeguards are established against the common dangers of impoverished and contaminated milk."

Rosenau defines *certified milk* as "*the very best, the very freshest, the very cleanest, the very purest and the very safest raw milk* that it is possible to produce." Professor Rosenau of Harvard University, in collaboration with Professor Pearson of Cornell University, defined "certified milk" and laid down certain requirements for its production which are given below:—

Certified milk is fresh, clean, pure, normal milk, of uniform composition and highest quality, obtained from healthy cows; produced and handled, under the supervision of a medical milk commission, with special sanitary precautions in accordance with the following general requirements and special conditions:—

GENERAL REQUIREMENTS.

Certified milk shall be produced by a trustworthy dairyman in accordance with a code of requirements prescribed by a medical milk commission. The dairyman shall enter into a legal contract with the commission, in which he shall agree to comply with all its requirements.

Certified milk shall be obtained from healthy, tuberculin-tested cows under veterinary inspection; all persons who directly or indirectly come in contact with the milk shall be under medical supervision; and the milk itself shall be subjected to periodical bacteriological, chemical, and other tests.

[1] Henry L. Coit. *blic Health*, 1909, Vol. XXIII, p. 93.

Certified milk should be free from harmful germs and shall contain relatively few of the common bacteria. It should not contain more than 10,000 bacteria per cubic centimetre, and shall not contain on an average more than 10,000 bacteria per cubic centimetre, this average shall be based upon bacteriological examinations covering a period of ninety days, and the counts shall be made at least once a week during this time.

Certified milk must be bottled at the point of production, rapidly chilled, kept cold, and delivered promptly to the consumer. After it is once chilled, the temperature of certified milk should at no time go above 45°F, but never below 32°F.

Certified milk shall be normal milk; that is, neither heated, frozen nor altered in any way except strained and cooled.

Certified milk shall be of uniform quality and contain not less than 3.8 per centum nor more than 4.2 per centum of fat, unless it is labelled otherwise, in which case it shall not vary more than 0.2 per centum from the amount stated on the label.

Certified milk shall not be subjected to the action of heat; shall not be subjected to the action of any preservative whatever, except cold; shall not be subjected to the action of light, electricity, pressure, or any special force or agency of any kind for any purpose; no substance of any kind shall be added to the milk for any purpose; and no part of the milk shall be removed.

As regards *special requirements,* the following regulations of the milk commission of the Medical Society of the County of New York will serve well as a model :—

1. *The barn-yard.*—The barn-yard should be free from manure and well drained, so that it may not harbour stagnant water. The manure which collects each day should not be piled close to the barn, but should be taken several hundred feet away. If these rules are observed, not only will the barn-yard be free from objectionable smell, which is an injury to the milk, but the number of flies in summer will be considerably diminished.

These flies are an element of danger, for they are fond of both filth and milk, and are liable to get into the milk after having soiled their bodies and legs in recently visited filth, thus carrying it into the milk.

Flies also irritate cows, and by making them nervous reduce the amount of their milk.

2. *The stable.*—In the stables the principles of cleanliness must be strictly observed. The room in which the cows are milked should have no storage loft above it; where this is not feasible, the floor of the loft should be tight to prevent the sifting of dust into the stable beneath. The stables should be well ventilated, lighted, and drained, and should have tight floors preferably of cement, never of dirt. They should be white-washed inside at least twice a year, unless the walls are painted or of smooth cement finish, which can be washed frequently.

The air should always be fresh and without bad odour. A sufficient number of lanterns should be provided to enable the necessary work to be properly done during the dark hours. The manure should be removed twice daily, except when the cows are outside in the fields the entire time, between the morning and afternoon milkings. The manure gutter must be kept in a sanitary condition. All sweeping must be finished before the grooming of the cows begins, so that the air may be free from dust at the me of milking.

There should be an adequate supply of water, warm and cold, and the necessary wash-basins, soap, and towels.

3. *Water supply.*—The whole premises used for dairy purposes as well as the barn must have a supply of water absolutely free from any danger of pollution with animal matter and sufficiently abundant for all purposes, and easy of access.

4. *The Cows.*—No cows will be allowed in the herd furnishing certified milk except those which have successfully passed a tuberculin test. All must be tested at least once a year by a veterinarian approved by the milk commission. Any animal suspected of being in bad health must be promptly removed from the herd and her milk rejected. Do not allow the cows to be excited by hard driving, abuse, loud talking, or any unnecessary disturbance.

Feed.—Do not allow any strongly-flavoured food, like garlic, to be eaten by the cows.

When ensilage is fed, it must be given in only one feeding daily, and that after the morning milking, and the full ration shall consist of not more than 20 pounds daily for the average-sized cow. When fed in the fall, small amounts must be given and the increase to the full ration must be gradual.

Cornstalks must not be fed until after the corn has blossomed, and the first feedings must be in small amounts and the increase must be gradual. If fed otherwise, ensilage and cornstalks are liable to cause the milk to affect children seriously.

Cleaning.—Groom the entire body of the cow daily. Before each milking wash the udder with a cloth used only for the udders, and wipe it with a clean dry towel. Never leave the udder wet, and be sure that the water and towel used are clean. The tail should be kept clean by frequent washing. If the hair on the flanks, tail, and udder is clipped close, and the brush on the tail is cut short, it will be much easier to keep the cow clean. The cows must be kept standing after the cleaning until the milking is finished. This may be done by a chain or a rope under the neck.

5. *The milkers.*—The milker must be personally clean. He should neither have, nor come in contact with, any contagious disease while employed in handling the milk. In case of any illness, in the person or family of any employee in the dairy, such employee must absent himself from the dairy until a physician certifies that it is safe for him to return.

In order that the milk commission may be informed as to the health of the employees at the certified farms, the commission has had postal cards printed, to be supplied to the farms, and to be filled out and returned each week by the owner, manager, or physician of the farm, certifying that none are handling the milk who are in contact with any contagious disease.

Before milking, the hands should be washed in warm water with soap and nail brush and well dried with a clean towel. On no account should the hands be wet during milking.

The milkers should have light-colored, washable suits, including caps, and not less than two clean suits weekly. The garments should be kept a clean place, protected from dust, when not in use.

Iron milking stools are recommended and they should be kept clean.

Milkers should do their work quietly and at the same hour morning and evening. Jerking the teat increases materially the bacterial contamination of the milk, and should be forbidden.

6. *Helpers other than milkers.*—All persons engaged in the stable and dairy should be reliable and intelligent. Children under twelve should not be allowed in the stable or dairy during milking, since in their ignorance they may do harm, and from their liability to contagious diseases they are more apt than older persons to transmit them through the milk.

7. *Small animals.*—Cats and dogs must be excluded from the stables during the time of milking.

8. *The milk.*—All milk from cows sixty days before and ten days after calving must be rejected.

The first few streams from each teat should be discarded in order to free the milk ducts from the milk that has remained in them for some time and in which the bacteria are sure to have multiplied greatly. If any part of the milk is bloody or stringy or unnatural in appearance, the whole quantity yielded by that animal must be rejected. If any accident occurs in which a pail becomes dirty, or the milk in a pail becomes dirty, do not try to remove the dirt by straining, but put aside the pail, and do not use the milk for bottling, and use a clean pail.

Remove the milk of each cow from the stable, immediately after it is obtained, to a clean room and strain through a sterilised strainer of cheese-cloth and absorbent cotton.

The rapid cooling is a matter of great importance. The milk should be cooled to 45°F within an hour and not allowed to rise above that as long as it is in the hands of producer or dealer. In order to assist in the rapid cooling, the bottles should be cold before the milk is put into them.

Aeration of milk beyond that obtained in milking is unnecessary.

9. *Utensils.*—All utensils should be as simple in construction as possible, and so made that they may be thoroughly sterilised before each using.

Coolers, if used, should be sterilised in a closed steriliser, unless a very high temperature can be obtained by the steam sent through them.

Bottling machines should be made entirely of metal with no rubber about them, and should be sterilised in the closed steriliser before each milking or bottling.

If cans are used, all should have smoothly soldered joints with no places to collect the dirt.

Pails should have openings not exceeding 8 inches in diameter, and may be either straight pails, or the usual shape with the top protected by a hood.

Bottles should be of the kind known as "common sense," and capped with a sterilised paraffined paper disk and the caps authorised by the commission.

All dairy utensils, including the bottles, must be thoroughly cleansed and sterilised. This can be done by first thoroughly rinsing in warm water, then washing with a brush and soap or other alkaline cleansing material and hot water, and thoroughly rinsing. After this cleansing they should be sterilised by boiling, or in a closed steriliser with steam, and then kept inverted in a place free from dust.

10. *The dairy.*—The room or rooms where the utensils are washed and sterilised and milk bottled should be at a distance from the house, so as to lessen the danger of transmitting through the milk any disease which may occur in the house.

The bottling room, where the milk is exposed, should be so situated that the doors may be entirely closed during the boiling, and not opened to admit the milk nor to take out the filled bottles.

The empty cases should not be allowed to enter the bottling room nor should the washing of any utensils be allowed in the room.

The workers in the dairy should wear white washable suits, including cap, when handling the milk.

Bottles must be capped, as soon as possible after filling, with the sterilised disks.

Definite chemical and bacterial standards have been adopted for certified milk. The numerical standard for bacteria in most cases is a maximum limit of 10,000 microbes per cubic centimeter. The average price of certified milk in the United States is about 16 cents (8 annas) a quart, or 3 annas and 2 pies per pound. The

amount of certified milk produced in the large American cities forms about one per cent. of the total supply. Some of the States have enacted laws concerning certified milk.

The production of certified milk under the auspices of Medical Milk Commissions has been found to be a great stimulus for the improvement of the general milk supply of American cities. The cost of producing certified milk in India would be very high as it would necessitate the employment of a dairy expert, a chemist, a bacteriologist, a veterinary surgeon and trained dairymen. If carried on co-operative basis with the help of Government and the local municipality, it would be quite possible to produce " certified " milk at a moderate cost. A model dairy under the supervision of a milk commission would be also of great educative value. Such a dairy would be useful in demonstrating the most modern methods of producing pure milk. The standards proposed for " certified " milk in India are mentioned under " Legislative Control."

III. LEGISLATIVE CONTROL, *including milk inspection and legal milk standards.*

The question of controlling the milk trade by means of legislation has been only recently considered in India. In most European countries and in America, milk legislation has been in force for a considerable time. The consideration of the legislative side of the milk question has been reserved to the last as the author believes that the economic, sanitary and other remedial measures for the production and supply of clean and wholesome milk should *precede* legislation ; for, unless there is an adequate provision for the economic production of clean milk, legislation alone is not likely to effect much good. It would be beyond the scope of this memoir to describe in detail the various laws and regulations that it would be necessary to enact for the efficient control of the milk trade. All that would be attempted here is to state some of the fundamental principles underlying milk control which may serve as a guide to the legislators. The laws and regulations affecting the milk problem in Indian cities may be framed for the purpose of carrying out at least the following objects :—

(1) To regulate and control the quality and the quantity of the entire city milk supply—both local and imported—by means of registration of all milk producers, dealers, etc.

(2) To provide for the sanitary control of the production, transit and distribution of milk, by means of licenses, permits, etc.

(3) To insist on certain sanitary requirements for the housing of milch cattle, and to provide for their periodic examination by duly qualified Veterinary Surgeons.

(4) To restrict the export of valuable Indian milch cattle to foreign countries, at least for the present, and to secure the best milking animals in this country.

(5) To minimise the evil of the slaughter of dry cows and buffaloes of dairying value.

(6) To prohibit the location of milch cattle stables in the crowded areas of the cities.

(7) To provide, if possible, for the medical supervision of all persons who come in contact with the milk.

(8) To prevent the abstraction of any constituent of milk, or the addition of any extraneous substance thereto, and to fix legal milk standards.

(9) To preserve the purity of milk, to prevent its contamination with stable dung and any other filth, and to provide for the microscopic and bacteriological examination of milk.

(10) To require sanitary handling of milk in order to prevent it from acting as a vehicle of any specific disease, *e.g.*, Cholera, Typhoid fever, etc.

(11) To prohibit the addition of chemical preservatives to milk.

(12) To provide for an efficient system of milk inspection, and to require certain qualifications and training for milk inspectors.

(13) To improve the existing administrative powers of the local Municipalities so as to enable them to exercise an effective sanitary and legal control of the public milk supply.

(14) To appoint Milk Commissions in the different Provinces.

Objects (1) and (2) have been partially fulfilled recently in Bombay,[1] by making it obligatory for milk sellers, etc., to obtain a license which is issued on certain conditions. The form of license required in Bombay will be found in Appendix C. (*q.v.*).

It will be seen that this does not give sufficient control over the milk that is imported into the city. Only such milk should

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[1] *Vide* Bombay Act No. VI of 1913. Bombay Government Gazette, 2nd October, 1913

be allowed to be sold in the city as has been produced in accordance with the required sanitary regulations. For this purpose it would be necessary to extend the legal control to the place of production. In addition, provision may be made for the registration of all milk producers, dealers and vendors.

With regard to (3), the Bombay Municipal Corporation have enacted certain bye-laws relating to milch cattle stables (*vide* Appendix D). These bye-laws are applicable only to those who hold a license for a cattle stable in Bombay city. The milk dealers who import milk from the suburban districts are not under any obligation to have their milch cattle housed and cared for according to these bye-laws. This is a great drawback, particularly when it is hoped that, in course of time, most of the milch cattle stables will be located outside the city. At present there is neither any sanitary supervision nor any legislative control over the milch cattle and their stables in the suburban districts which supply the city with milk. It is suggested that some legal provision may be made by which the city authorities could control the production of milk in the suburbs. For example, no imported milk should be allowed to be sold in Bombay which has not been produced according to sanitary requirements. The milk license could be refused or revoked in such cases.

Some of these bye-laws may require some revision and modification after watching their practical effects for some time. For instance, under 6 (*e*) we find: " it (stable) shall be so constructed as to afford floor space not less than twelve-and-a-half feet in length by five feet in breadth for each cow or buffalo to be stabled therein," etc. These dimensions, perhaps, may be modified. The space required for a cow may be reduced by at least 1 foot all round with advantage. The exact division of this space may be specified separately for the feeding trough, stall, the manure gutter, and the passage, etc. If each animal be partitioned off from its neighbour, it would mean more cleanliness of the stable as well as that of the animals, and this may be inserted as a requirement. (See Plate XXXI).

Provisions (4), (5) and (6) are necessary for the *economic* production of milk. They have been briefly considered in the previous chapters, as well as in the beginning of this chapter. The keeping of milch cattle within the city limits is forbidden by

law in almost all the Municipalities in America,[1] where the milk supply is known to be under the most rigid sanitary and legal control. The disadvantages of keeping milch cattle in the cities have been already pointed out. The cost of upkeep being too high in the cities, it is financially impossible to maintain dry animals or young stock there. This leads to the sale of such animals to the butchers, which, as stated before, is a very disastrous practice devastating our best breeds of milch cattle. With reference to this, Professor Knight, of the Poona College of Agriculture, and Mr. Horne,[2] say: "As a remedy to such a state of affairs, we consider that the keeping of cattle for the public supply of milk, within such cities as Bombay, should be prohibited by law. If this were done, the milk producers would be forced to locate at a distance, where succulent fodder could be obtained and that too so cheaply as to permit the retention of dry animals, and the rearing of young stock. Co-operative methods of delivering would be forced upon them, simplifying the control. By the removal of all dry animals from the city, the cost of production would be lowered; under co-operative action the cost of delivery would also be less, the cost of cattle be reduced, and cleanliness of the product and ease of control and supervision would all follow in natural sequence."

(7) *Medical supervision of all persons engaged in the production and distribution of milk* is particularly desirable in India, where the milkmen are likely to act as "carriers" of infectious diseases, *e.g.*, cholera, typhoid fever, tuberculosis, etc. The Medical Milk Commissions of America have a medical officer in connection with the dairies producing "certified milk" who is known as the attending dairy physician. This officer has to report from time to time regarding the health of the people working in the dairy and to enforce the ordinary rules of personal hygiene. According to one of the regulations,[3] "No person shall be employed who has not been vaccinated recently or who upon examination is found to have a sore throat, or to be suffering from any form of tuberculosis, venereal disease, conjunctivitis, diarrhœa, dysentery, or who has recently had typhoid fever or is proved to be a typhoid carrier, or who has any inflammatory disease of the respiratory tract, or any suppurative process or infectious

[1] Rosenau. The Milk Question. 1902, p. 261.
[2] J. B. Knight, M.Sc., and E. W. Horne, Dept. of Agriculture: Bombay, Bulletin No. 56 of 1913. "Present state of the Dairying Industry in Bombay," p. 12.
[3] William Ernst. "Milk Hy iene," p. 269.

skin eruption, or any disease of an infectious or contagious nature, or who has recently been associated with children sick with contagious disease."

(8) Until recently, there was no *legal provision* in Bombay *for the prevention of adulteration of milk.* In 1899 an Act was passed, known as Bombay Act No. II of 1899, for the purpose of preventing the adulteration of *ghee* and other articles of human food (*vide* Appendix E.) This Act is based on the English Sale of Food and Drugs Act of 1875 and 1899. The provisions of this Act applied only to ghee until 1st April, 1912, when by Government Notification No. 1321, dated 27th February, 1912, the provisions of this Act were made to apply also to milk in the city of Bombay. Dr. Turner, the Executive Health Officer of the Bombay Municipality, commenting on the defects of the Act says,[1] "In practice the working of this Act has been found to be defective, and it has not served the object for which it was passed." He points out that certain amendments in Section 4 of the Act are necessary in order to provide for the analysis of the samples of milk being made by the Municipal Analyst instead of by the Chemical Analyser to Government, and also to make some provision for the Municipal Officers to be able to purchase samples of milk by the hands of a deputy, so that the vendors may not know for what purpose they are being bought. He suggests the following amendments in Section 4 :—

"In Sub-section (1) substitute for the word 'officer' where it first occurs, the word 'person.'

"In Sub-section (2) substitute for the word 'officer' where it first occurs, the word 'person,' and after the word 'analysed' where it first occurs, introduce the words 'in the City of Bombay by the Municipal Analyst, and elsewhere,' and after the same word where it for the second time occurs, introduce the words 'in the City of Bombay to the Municipal Analyst and elsewhere.'

"In Sub-section (3) for the words 'the Chemical Analyser to Government' substitute the words 'the Municipal Analyst or Chemical Analyser to Government as the case may be.'"

There are no chemical standards for milk in India which are officially recognised by Government. It would be necessary to legalise such standards as pointed out by the author at the Third All-India Sanitary Conference[2] in January 1914. The

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[1] J. A. Turner, M.D., D.P.H. "Sanitation in India," 1914, p. 452.

[2] "Observations on the Bacteriological and Chemical Examination of Bombay Milk Supply." by Dr Lemuel Lucas Joshi, M.D., B. Sc., &c. (Lucknow).

milk standards in Great Britain have been fixed by the Board of Agriculture in exercise of the powers conferred upon them by section 4 of the Sale of Food and Drugs Act, 1899. The milk standards for India may be fixed by "Milk Commissions" as suggested on page 211. The question of chemical standards has been fully discussed in Chapter III. The average analytical figures obtained from a systematic analysis of several hundreds of *genuine* samples of milk in Bombay and Poona have been mentioned. The following standard is proposed for legal purposes for Bombay, Poona and other cities in Western India :—

Milk, as is ordinarily obtained in the market, shall be considered genuine if it is found to contain at least five per cent. of fat and not less than eight and a half per cent. of non-fatty solids, provided that the percentage of fat may be allowed upto three and a half, only when it is proved to the satisfaction of the court that the sample was one of unmixed cows' milk, the onus of the proof resting with the vendor.

The standard may be also expressed as follows in connection with the *proposed amendments to Bombay Act No. II of* 1899 :—

"Sale of Milk" Regulations.

(Applicable to Bombay Presidency only.)

1. Where a sample of milk (not being milk sold as skimmed, or separated, or condensed milk) contains less than five per cent. of milk fat, it shall be presumed for the purposes of this Act, until the contrary is proved, that the milk is not genuine, by reason of the abstraction therefrom of milk fat, or the addition thereto of water, *provided* that the lowest legal limit for milk fat, in milk exclusively derived from cows, shall be three and a half per cent.

2. Where a sample of milk (not being milk sold as skimmed, or separated, or condensed milk) contains less than eight and a half per cent. of milk solids other than milk fat, it shall be presumed for the purposes of this Act, until the contrary is proved, that the milk is not genuine, by reason of the abstraction therefrom of milk solids other than milk fat, or the addition thereto of water.

(9) and (10) *Legal provision to prevent the contamination of milk with pathogenic microbes and with bacteria indicating stable dung or any other dirt.*—No such provision exists at present. The practical importance of the bacteriological examination of milk has been pointed out in Chapter IV. The dirt content of milk

is sometimes determined by filtration (*e.g.*, with "Gerber's dirt tester") or by sedimentation by the centrifuge. The latter method was used by Delépine[1] for estimating the amount of dirt in Manchester milk. Such methods may be used for getting a rough idea of the gross dirt present. A great deal of the dirt, however, is dissolved in the milk[2] which cannot be determined by these methods. Besides, the sediment is not composed entirely of dirt but also of other substances, such as the cellular elements, which are natural to milk. Another objection is that the amount of sediment depends on the efficiency of straining, and therefore is not a reliable measure of the cleanliness of the methods used in handling milk. According to Savage, "straining as a purification process is most irrational. The dung gives up a large part of its bacterial content to the milk, the only part of it which is prejudicial, and the residue is then strained off." He is of opinion "that the measurement of the sediment or dirt (as it is often called) in milk is an estimation which it is of no material value to retain. It gives no information which cannot be obtained much better in other ways, while it is open to many and serious sources of error."[3] Even if the amount of sediment be accepted as a reliable measure of the dirt in milk, it cannot give any information regarding its character. This can be ascertained only by microscopic and bacteriological examinations. The results of the bacterial examination of Bombay milk and the practical significance of the presence of different bacteria in milk have been fully discussed in Chapter IV. A knowledge of the bacterial content of milk is essential in order to determine the age of the milk, the quantity and character of the dirt present, and the presence or absence of objectionable bacteria. It would also serve as an index of the cleanliness of the methods employed in the handling of the milk.

Pure Milk implies four separate requirements[4]:—

1. *Genuine Milk*—That is the whole milk without additions or abstractions.

2. *Milk* derived *from healthy animals.*

3. *Clean milk*—That is milk so collected, transmitted and vended that it is free, or reasonably free, from manurial or other objectionable pollution.

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[1] Delepine. Report to the Manchester Sanitary Committee, 1908.
[2] William Ernst. "Text Book of Milk Hygiene," 1914, p. 215.
[3] Savage. *Milk and the Public Health*, p. 201.
[4] Modified slightly from Savage's "Milk and the Public Health," 1912, p. 397.

4. *Milk free from infection* with the organisms of specific diseases, *e.g.*, Cholera, Typhoid fever, Tuberculosis, etc.

The first requirement is determined by chemical analysis, and the second by veterinary inspection. The third and fourth requirements can be determined only by a *bacteriological* examination of milk. Savage is of opinion that to ensure a reasonably clean milk supply, bacteriological examinations are essential, and nothing can take their place. Detection of dirty procedures is only possible by bacteriological examination.

The question of fixing *legal bacterial standards* for milk in India will have to be faced sooner or later. Unfortunately very little work has been done in this country regarding the bacteriology of milk. So far as the author is aware, the work described in Chapter IV is the first systematic attempt ever made in India for finding out the bacterial content of milk and for proposing certain bacterial standards. There is now a large number of well-equipped bacteriological laboratories in this country, and it is suggested that a systematic bacteriological examination of milk may be carried out there with a view of determining the local bacterial standards. In the meantime, so far as Bombay is concerned, it may be worth while to try the tentative bacterial standards proposed on page 72. If they are found to be useful and practical from the administrative point of view, they may then be legalised at least for the city of Bombay.

The proposed legal standards have been kept as low as possible. A real good grade of milk ought to give higher figures for butter-fat. As pointed out in Chapter III, a few samples of buffalo milk is known to give as much as 11 per cent. of fat, the average for buffaloes' milk being 7 to 8 per cent. It would be possible therefore to remove some of the fat and bring it down to the required legal standard (5 per cent.). Such a practice is quite common in England and in America, and is likely to be followed in India after the declaration of standards. Milk containing 5 per cent. fat, however, is quite nutritious so long as there is no addition of water. Besides, milk, from which a part of the cream (about one-third) has been removed, could be sold for a lower rate than milk containing all its cream. "Skimmed" or separated milk also can be used under certain conditions. Clean skimmed milk would be preferable to milk to which dirty water has been added. In order to prevent fraudulent extraction of

butter-fat and at the same time lower the price of milk, the following *three grades of milk are suggested* :—

1. *First Grade* or "*Certified*" *milk*.—This should contain at least 6.5 per cent. fat and 9 per cent. non-fatty solids. The number of microbes per c.c. should not exceed 100,000.

2. *Second Grade* or "*Ordinary*" *market milk*.—This should contain at least 5 per cent. fat and 8.5 per. cent non-fatty solids. In the case of cows' milk, the lowest limit of fat should be 3.5 per cent. The number of microbes per c.c. should not exceed 1,000,000.

3. *Third Grade* or "*Skimmed*" *milk*.—This should contain at least 9 per cent. of total solids.

All the three grades of milk must be *pure*, derived from healthy animals and free from dirt and adulteration as well as from pathogenic microbes.

(11) As regards the *addition of preservatives to milk*, the same practice may be followed here as in England, as mentioned in Public Health (Milk and Cream) Regulations, 1912. Article III of Part II (1) "forbids anyone to add, or order, or permit the addition of preservatives to milk intended for sale for human consumption;" and (2) "forbids anyone to sell, or expose or offer for sale, or have in his possession, any milk to which preservatives have been added." [1]

The Departmental Committee in England recommended the absolute prohibition of the use of any preservative in milk. The only preservative allowed in *cream* was boric acid in amount not exceeding 0.25 per cent.[2]

As mentioned in Chapter VI, many samples of milk imported into Bombay from long distances, *e.g.*, Gujarat, have been found to contain formaldehyde. Some legal provision is necessary to prohibit the addition of any chemical preservative to milk.

(12) *Milk Inspection*—This is an extremely important measure for the legal and sanitary control of the public milk supply. It is practically impossible to efficiently control the milk trade without the proper aid of milk inspectors. A **milk inspector** should possess certain educational qualifications and should have had a thorough training in the theory and practice of dairying and dairy hygiene. He should spend at least two

[1] Robertson and Porter. "Sanitary Law and Practice." 1912, p, 699.
[2] Savage. "Milk and the Public Health," p. 389.

years in training, taking animal husbandry and dairy hygiene as his special subjects. He should be acquainted with the ordinary laboratory methods of examining milk chemically and bacteriologically. After obtaining the necessary qualifications he should acquire some practical experience of the best methods, by working under an experienced inspector. A milk inspector must be not only *capable,* but also *thoroughly honest* and *conscientious.* It is, perhaps, needless to point out that it is not possible to get the right man on the low salaries usually given to inspectors in India. If an efficient sanitary supervision and a tactful enforcement of legislation is desired, then it would be worth while paying a good salary to the right man who would honestly carry out these objects.

The duties of milk inspectors consist mainly in (*a*) inspection of the dairies, milk shops, dairy farms, stables, milk-sheds, milk depots, etc.; (*b*) inspection of the milch cattle with special reference to the carrying out of the bye-laws, etc.; (*c*) taking of samples at the source after making a preliminary test; (*d*) inspection of milk utensils and all other dairy appliances used in the production of milk, with particular regard to the sanitary and legal requirements; (*e*) frequent inspection of milk during transit, and taking of samples occasionally; (*f*) inspection of market milk and taking of samples according to instructions and sending them for chemical and bacteriological examination to the Public Analyst; (*g*) keeping a careful record of all his observations and findings; (*h*) reporting on any breach of rules and regulations, including conditions of license, and arranging for taking legal steps when necessary; (*i*) making suggestions for improvement in the present methods of supervision and control; and (*j*) instructing the milk dealers and vendors in the sanitary and economic methods of dairying. It would not be possible for the ordinary sanitary inspector to carry out all these measures in addition to his own duties. The veterinary inspector is expected to examine the milch cattle from time to time. A trained milk inspector is therefore a great necessity. For a city like Bombay, at least ten such inspectors would be necessary—one for each district. The amount of milk to be supervised by one inspector would be about 25,000 pounds in the case of Bombay.

As outlined above, the duties of a milk inspector are not only to inspect and supervise, but also to *instruct.* The attitude of the inspector should not be that of a stern officer of law, whose sole object is to find fault, condemn, and take legal steps, but he

should show a sympathetic spirit, instructing the ignorant milkmen in modern methods of dairying and pointing out the advantages of clean methods, etc. He should use persuasion and tact rather than threats. At the same time he should be firm and appeal to law as a last resort.

The inspector must exercise great care and caution in *taking the samples of milk for analysis.* He should provide himself with three clean bottles, each having a capacity of not less than 8 ozs., and to which a blank label is affixed, to be filled up afterwards. Other necessaries are sealing-wax, string or tape, a spirit lamp or candle and the official seal of the Public Health Department. As far as possible, the samples should be purchased by the hands of a deputy so that the vendors may not suspect the purpose for which the purchase is made. The deputy may be some assistant who is capable of giving evidence intelligently in court. While the purchase is being made, the milk inspector stands within easy hearing distance. The purchaser must ask for pure milk. As soon as the required amount of milk (about one seer) is measured out and payment made, the inspector must announce that "this milk has been bought for the purpose of analysis by the Public Analyst." He should then divide the milk into three equal parts and put it up in the three bottles. After carefully sealing the bottles in the presence of the vendor, an inscription is written in ink upon the blank label affixed to each bottle, giving the number and description of the sample, date and time of purchase, name and address of the vendor and signature of the inspector. One of the bottles is left with the vendor, another is sent to the Analyst and the remaining one is retained by the inspector. If the milk is contained in a large can or vessel, care should be taken that it is well stirred before sampling, otherwise only the top-milk containing most of the cream might be purchased and thus lead to an error.

The Score-Card System.

"The score-card is a mathematical photograph of the sanitary conditions of the dairy farm." [1] The idea of the score-card was first conceived by Dr. W. C. Woodward, Health Officer of the District of Columbia, U.S.A. A little later, Professor R. A. Pearson of Cornell University, N. Y., introduced a different form of score-card which was adopted, with a few alterations, by the Dairy Division of the Bureau of Animal Industry. The size of this card is 8 by 5 inches and it is reproduced overleaf.

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[1] Rosenau. *The Milk Question.*

UNITED STATES DEPARTMENT OF AGRICULTURE,

BUREAU OF ANIMAL INDUSTRY,

DAIRY DIVISION.

SANITARY INSPECTION OF DAIRIES.

DAIRY SCORE CARD.

Adopted by the Official Dairy Instructors' Association.

Owner or lessee of farm ....

P.O. address ....State ....

Total number cows ....Number milking ....

Gallons of milk produced daily ....

Product is retailed by producer in ....

Sold at wholesale to ....

For milk supply of ....

Permit No..............................Date of inspection..............................191 .

REMARKS..

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(*Signed*)..

Inspector.

[*Front of Card.*]

DETAILED SCORE.

EQUIPMENT.	SCORE. Perfect.	SCORE. Allowed.
COWS.		
Health	6	....
Apparently in good health..1		
If tested with tuberculin once a year and no tuberculosis is found, or if tested once in six months and all reacting animals removed ... 5		
(If tested only once a year and reacting animals found and removed, 2.)		
Comfort	2	....
Bedding ... 1		
Temperature of stable ... 1		
Food (clean and wholesome)	2	....
Water	2	....
Clean and fresh ... 1		
Convenient and abundant.. 1		
STABLES.		
Location of stable	2	....
Well drained ... 1		
Free from contaminating surroundings ... 1		
Construction of stable	4	....
Tight, sound floor and proper gutter ... 2		
Smooth, tight walls and ceiling ... 1		
Proper stall, tie, and manger 1		
Means of lighting: Four sq. ft. of glass per cow	4	....
(Three sq. ft., 3; 2 sq. ft., 2; 1 sq. ft., 1 Deduct for uneven distribution.)		
Ventilation: Automatic system. Adjustable windows ... 1	3	....
Cubic feet of space for cow: 500 to 1,000 feet	3	....
(Less than 500 feet, 2; less than 400 feet, 1; less than 300 feet, 0; over 1,000 feet, 0.)		
UTENSILS.		
Construction and condition of utensils	1	....
Water for cleaning	1	....
(Clean, convenient, and abundant.)		
Small-top milking pail	3	....
Facilities for hot water or steam..	1	....
(Should be in milk house, not in kitchen.)		
Milk cooler	1	....
Clean milking suits	1	....
MILK ROOM.		
Location of milk room	2	....
Free from contaminating surroundings ... 1		
Convenient ... 1		
Construction of milk room	2	....
Floors, walls, and ceiling ... 1		
Light, ventilation, screens... 1		
Total	40	

METHODS.	SCORE. Perfect.	SCORE. Allowed.
COWS.		
Cleanliness of cows	8	....
STABLES.		
Cleanliness of stables	6	....
Floor ... 2		
Walls ... 1		
Ceiling and ledges ... 1		
Mangers and partitions ... 1		
Windows ... 1		
Stable air (dust and odours) at milking time	6	....
Barnyard clean and well drained.	2	....
Removal of manure daily to field or proper pit	2	....
(To 50 feet from stable, 1.)		
MILK ROOM.		
Cleanliness of milk room	3	....
UTENSILS AND MILKING.		
Care and cleanliness of utensils...	8	....
Thoroughly washed and sterilised in live steam for 30 minutes ... 5		
(Thoroughly washed and placed over steam jet, 4; thoroughly washed and scalded with boiling water, 3; thoroughly washed, not scalded, 2.)		
Inverted in pure air ... 3		
Cleanliness of milking	9	....
Clean, dry hands ... 3		
Udders washed and dried... 6		
(Udders cleaned with moist cloth 4; cleaned with dry cloth at least 15 minutes before milking, 1.)		
HANDLING THE MILK.		
Cleanliness of attendants in milk room	1	....
Milk removed immediately from stable	2	....
Prompt cooling (cooled immediately after milking each cow)	2	....
Efficient cooling below 50°F	5	....
(51° to 55°, 4; 56° to 60°, 2.)		
Storage; below 50°F	3	....
(51° to 55°, 2; 56° to 60°, 1.)		
Transportation; iced in summer.	3	....
(For jacket or wet blanket, allow 2; dry blanket or covered wagon, 1.)		
Total	60	....

Equipment..........................+Methods..........................=..........................**Final Score.**

NOTE 1.—If any filthy condition is found, particularly dirty utensils, the total score shall be limited to 49.
NOTE 2.—If the water is exposed to dangerous contamination, or there is evidence of the presence of a dangerous disease in animals or attendants, the score shall be 0.

The detailed score is given on the back of the card and is divided into two parts: *equipment* and *methods.* The marks given for equipment indicate the health of the animals, provision for their food, etc., the construction of stables, and the quality, etc., of the milk utensils and other dairy appliances used. The score for methods gives a fairly accurate idea of the manner in which the dairyman handles his milk, and comprises the condition of the stable, of the milk vessels, of the milkers, etc., and cleanliness of the animals. It will be noticed that 40 points or marks are allowed for equipment while 60 are allowed for methods, so that even if a person has poor equipment, he can score high by clean methods.

The following are the principal *advantages of the Score-Card System* as mentioned by the Bureau of Animal Industry, U. S. A., (Dairy Division):—

(1) It serves as a guide to the inspector in pointing out various conditions, and making it impossible for him to overlook any point of importance.

(2) It provides the Health Officer with a permanent, accurate and convenient record of all the dairies in his district.

(3) It may be used as a basis for issuing licenses or permits to sell milk.

(4) It promotes co-operation between the producer and the Health Authorities.

(5) It serves as a check upon the work of the inspectors.

(6) " The score-card is the salvation of the producer in the case of an incompetent or dishonest inspector, because he has a written record of his faults of commission and omission. On the other hand, the score-card protects the inspector against unreasonable attacks from the producer."

(7) It is a valuable means of improving dairy conditions. Information as to the conditions in the dairies could be tabulated and the scores published from time to time so as to give the dairymen every credit for their efforts to produce clean milk. This would also help the public to distinguish between high-class dairies and poor dairies.

In commenting on the score-card, Rosenau says: " Methods are much more important than equipment. This is one of the things that the score-card does not take into sufficient account. Clean milk may be produced with clean methods and poor

equipment, but good milk cannot be produced with a good equipment and poor methods."

The score-card system of dairy inspection is in use by about one hundred and fifty cities and large towns in America and is recognised by the United States Government. The score-card reproduced above has reference only to the production of milk in the dairies and dairy farms. Special score-cards could be devised for inspection of milk during transit, in milk depots, in the city dairies and milk shops, and throughout its distribution to consumers. The score-card system of America, with some modifications, may be tried for the control of the milk supply of Indian cities. The system should be given a thorough trial before adopting it legally.

(13) *Improvement in the existing administrative powers of the local municipalities, etc.*—The necessity for this is quite obvious. The duty of supervising the city milk supply, including laboratory examinations, veterinary and sanitary inspections, devolves upon the local health authorities; and if an efficient sanitary and legal control is desired, it would be necessary to strengthen the hands of the Public Health Department. It would seem desirable to give sufficient power to the local health authorities to *enforce* the sanitary and legislative measures without many technical difficulties and with the least possible delay.

(14) *The appointment of Milk Commissions* in the different Provinces to study in detail the milk problem in its various phases and to propose practical remedial measures for its solution. The Commission should be empowered: (1) to fix the legal standards; (2) to determine all questions regarding feeding, breeding, and housing, etc., of cattle; (3) to arrange the details of the sanitary control of the milk supply by means of inspection, etc.; and (4) to study the local conditions and make definite proposals for improvement in the present methods of handling milk.[1]

The supply of pure milk at a reasonable rate to our cities is thus a complicated problem, and its ultimate solution would depend upon the practical application of the various remedial

[1] As regards the Bombay Presidency, it is suggested that the Commission should include the Director of Agriculture, the Sanitary Commissioner with the Government, the Municipal Commissioner of Bombay, the Executive Health Officer of Bombay, the Agricultural Chemist to Government, the Superintendent of the Civil Veterinary Department, the Chemical Analyser to Government, the Municipal Analyst for the City of Bombay, the Managers of the Government Military and Civil Dairies at Kirkee, the Registrar or Assistant Registrar of Co-operative Societies, and two representatives elected by private dairying concerns.

measures. If milk is produced under economic conditions with proper supervision, it is not likely that the price would rise appreciably. But even if it should rise, it must be remembered that the *quality* would be superior, and one seer of genuine and clean milk produced under sanitary conditions is certainly preferable to two seers of watered and filthy milk. If sanitary reforms and improvements cause an increase in the cost of production of milk, it is but fair that the consumer should be willing to pay a reasonable price for it. The organisation of suitable agencies for the production and distribution of milk and the provision of improved facilities for its cheap and sanitary transport to the cities, should result not only in the improvement in the quantity and quality of the present milk supply, but also in a reasonable reduction in its price. A great deal would depend, of course, upon the local conditions. A study of the possible sources of cheap milk supply and of the best methods for organising it, etc., would be necessary in the case of each particular city.

Taking, for instance, the city of Bombay, there are at least two sources from which an ample supply of milk at a low cost is available. In the villages of Gujarat, milk is both abundant and cheap. It appears that good milk can be purchased in the villages near Ahmedabad, Nadiad, Anand, etc., at the rate of 20 to 25 lbs. per rupee. Being near the railway line, and even with the present facilities for transit, milk from these places can be imported into Bombay with profit. Another source of cheap milk supply is even nearer Bombay, namely, the villages near Thana, Kalyan, etc., as well as a few places above the Ghauts, such as Talegaon.

The production of milk within the city limits could be also improved by proper organisation. While it is desirable to locate the milch cattle stables outside the city as far as practicable, it is not absolutely necessary to remove all of them, provided that they occupy only the thinly populated or non-residential areas of the city. It appears that there are a few large vacant spots in the northern part of the city, which are not likely to be developed as residential areas and which may be well utilised for the purpose of dairying. Early in 1914 a scheme for creating a centre in an isolated part of the city for the location of new milch cattle stables under Municipal supervision was discussed. A large plot of land on the north-east of Haines Road, in close proximity to the Mahaluxmi Station on the B. B. & C. I. Railway, was suggested. It appears that this plot would accommodate between

7,000 to 8,000 animals. There is very little likelihood of this becoming a residential area. Being near a railway station it would be convenient for transit. It is suggested that as an experimental measure modern cattle sheds for 500 animals may be constructed on part of this or any similar plot, and the city *gowlees* may be induced to rent them at a nominal rent—say,—8 annas a month or Rs. 6 per year per animal.[1] Taking the cost of construction at Rs. 100 to Rs. 150 per animal, the proposed rent would bring in sufficient interest on the capital invested. The *gowlees* could be organised into co-operative societies as indicated above. A close sanitary supervision would be, of course, necessary. The societies should provide for rapid transit by means of railway trains, tram-cars, motor-waggons, etc. They should also arrange for the marketing of the milk in Bombay.

The proposed milk inspectors could supervise the entire milk supply from its source to its destination. The facilities for pure water supply and the provision for drainage would be additional advantages. The cost of transit would also be less, and there would be no need of pasteurising the milk as the time elapsing between milking and delivery would be comparatively short.

A similar scheme may be tried for the improvement of the suburban milk supply. Co-operative societies of the cultivators could be formed in the suburbs, *e.g.*, Andheri, Borivili, Palghar, Bhandup, Kalyan, etc., where milk could be produced under cheap and natural conditions. The milk could be brought into the city by means of one of the agencies already described. Pasteurisation would not be usually necessary for the *preservation* of milk during transit as the distances are short and transit by railway is available. Pasteurisation, however, may be necessary for *purifying* the milk after its arrival in the city. If milk has been produced and handled under clean conditions in the suburbs, then there would be no need of pasteurisation. In any case, it is suggested that as an experimental measure, the Municipality should establish a few distributing depots or "milk markets" in the city, where milk could be kept in cold storage, pasteurised if necessary, and sold to the public at market rates. Samples of milk should be taken from the source as well as at its destination and examined chemically and bacteriologically at the Municipal

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[1] From enquiries made at several cattle stables in Bombay it appears that the average ren charged is about Rs. 5 per month or Rs. 60 per year per animal.

Laboratory. The laboratory findings and the reports of the inspectors would give a definite idea regarding the quality of the milk and the conditions under which it has been handled. If the experiment proves a success from the economic as well as from sanitary points of view, then similar organisations could be enlarged and multiplied. While it would be necessary for the Municipality to exercise legislative control and sanitary supervision over the milk trade, the entire "municipalization" of the milk supply of our cities is considered undesirable for various reasons.

In Calcutta, the question of establishing Municipal grazing farms, Municipal milk depots, pasteurising plants, etc., was considered carefully by a special committee appointed to enquire into the question of the milk supply of that city. Among their conclusions and recommendations are the following :—

(1) Depots for the sale of pure milk and milk products should be established in Municipal markets, private markets and on Municipal lands at suitable centres, stalls being let out at reduced rents.

(2) Municipal dairy farms cannot be established under the law and should not be started till the Act is amended.

(3) Municipal purifying (pasteurising or sterilising) plant should be installed. It affords protection against harmful bacteria but discourages attempts for the production of clean milk. The efforts of the Municipality should be directed to the improvement of the conditions under which milk is produced.

(4) Municipal grazing farms cannot be provided as there are no suitable pasture lands near Calcutta. Power should be taken under the Act to subsidise grazing farms outside Calcutta and to open grazing grounds inside or outside Calcutta.

(5) Railway authorities should be asked to assist in the transportation of milk by providing special vans, fast trains and concession rates.

(6) Enquiries should be made to ascertain whether the Tramways Company will assist the Corporation in improving the transport arrangements for milk.

It appears that all suggestions made by the Corporation of Calcutta, on the recommendation of the special committee, have been accepted by the Government of Bengal and incorporated in the Calcutta Municipal Act Amendment Bill, with the exception of the proposal for licensing and the establishment

by the Corporation of cowsheds and dairies outside Calcutta for the supply of milk to the city. This proposal is still under consideration.

A special committee has been recently appointed by the Government of Bombay to consider the question of the milk supply of large towns in the Bombay Presidency, and more particularly:

"(i) To indicate the most suitable localities in which scientific dairying can be undertaken with reference to: (*a*) the demand for good milk, (*b*) the possibility of obtaining a supply of good fodder, (*c*) transport facilities.

"(ii) To indicate the agency by which such operations can be most profitably undertaken and the exact nature of Government assistance that would be required to give them a fair start.

"(iii) To indicate the best methods of organising and controlling the existing agencies which supply milk to large cities."

The organisation of the sanitary production of milk by village cultivators, gowlees and others keeping milch animals under natural conditions; adequate assistance from Government and Municipalities; considerable improvement in the transport of milk to the cities; the establishment of large dairying concerns for the purpose of importing and distributing milk; and complete sanitary control by the Municipality of the entire milk supply of the city seem to afford the best prospects for a satisfactory solution of the milk problem. The agriculturist, the gowlee, the dairyman, the scientist, the practical sanitarian, the economist and the legislator, individually and jointly, must study the problem thoroughly from various points of view, and work out the most suitable remedial measures. Then alone, by systematic and persistent effort, by broad education and scientific research, by intelligent organisation and co-operation, by efficient sanitary supervision and tactful legislation, would it be possible to bring about a practical solution of the milk problem in Indian cities.

The author is aware that there are many practical difficulties in the way of applying the proposed remedial measures, but these difficulties are not insuperable, nor do they in any way invalidate the general principles laid down in the foregoing pages.

PLATE I.
MURRAH OR DELHI BUFFALO.

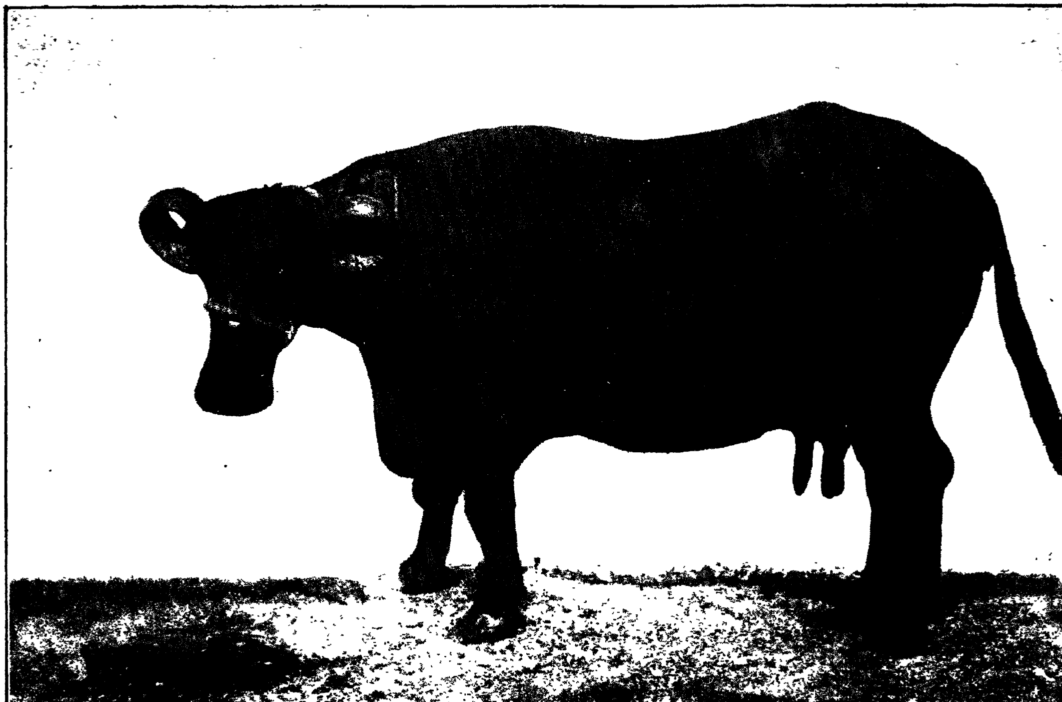
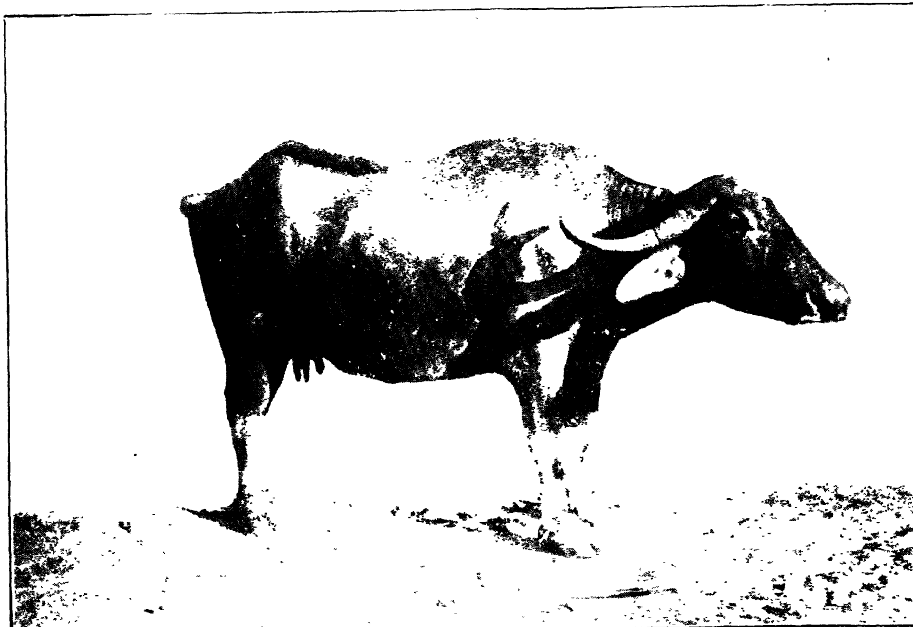


PLATE II.

SURTI BUFFALO.



From a Photograph taken in Bombay.

PLATE III.
JAFFRABADI BUFFALO

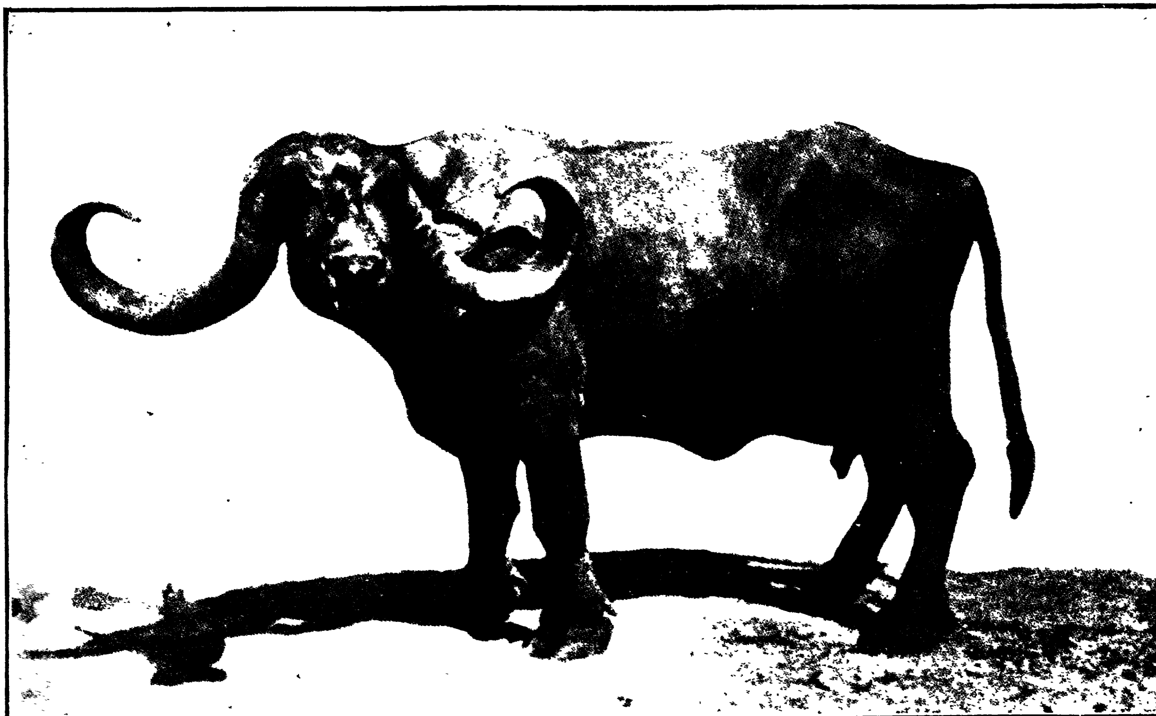


PLATE IV.

MEHSANA BUFFALO.

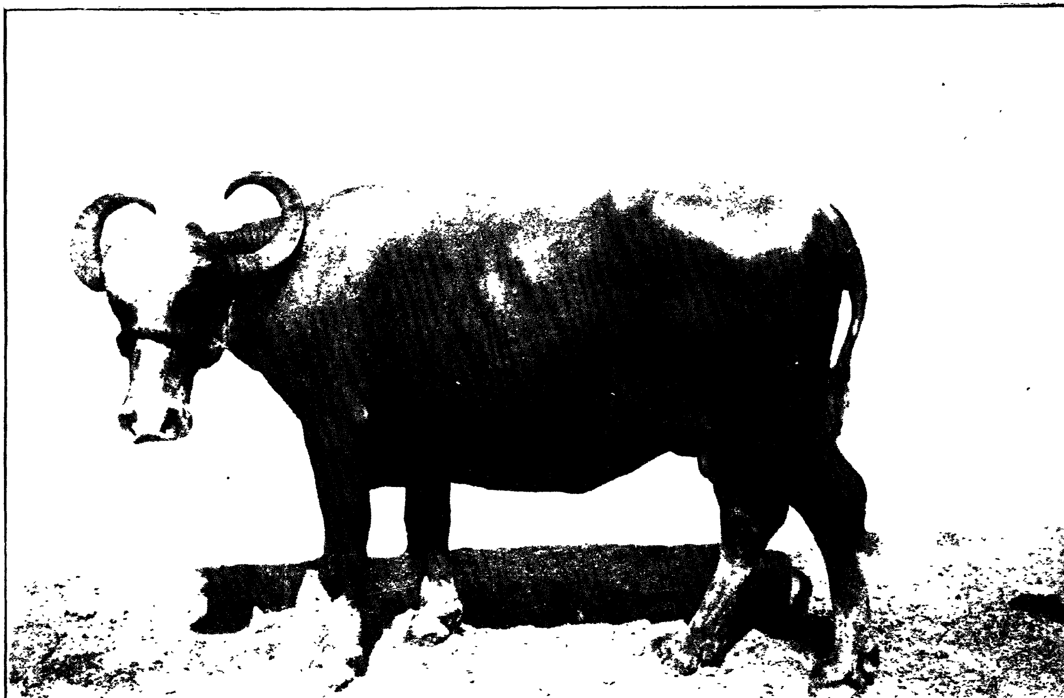


PLATE I

SINDHI COW.

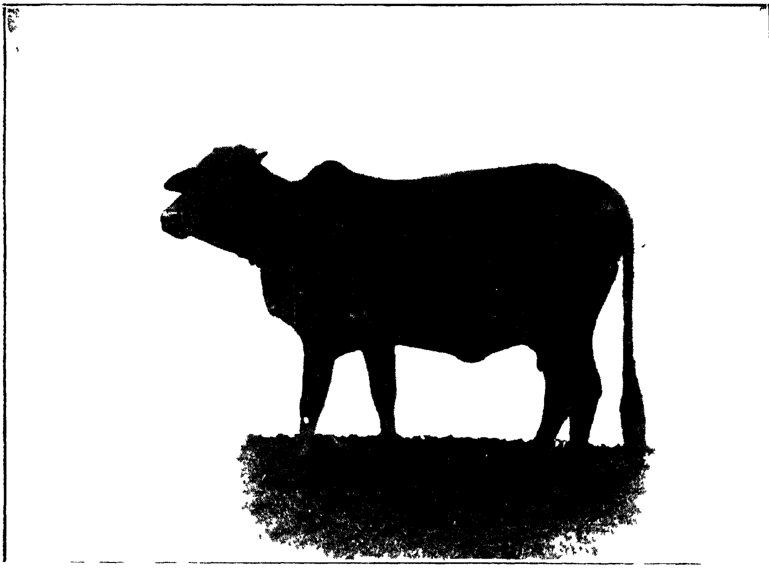
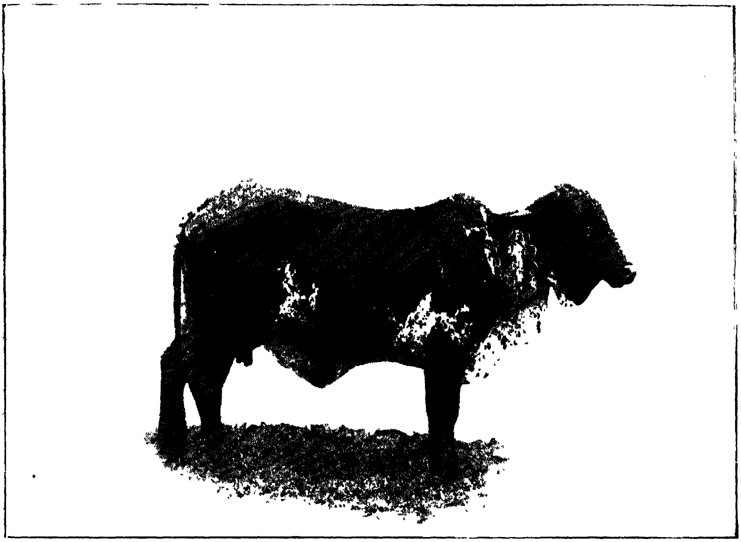


PLATE XIII

HALF BRED COW (Ayrshire and Sindhi.)

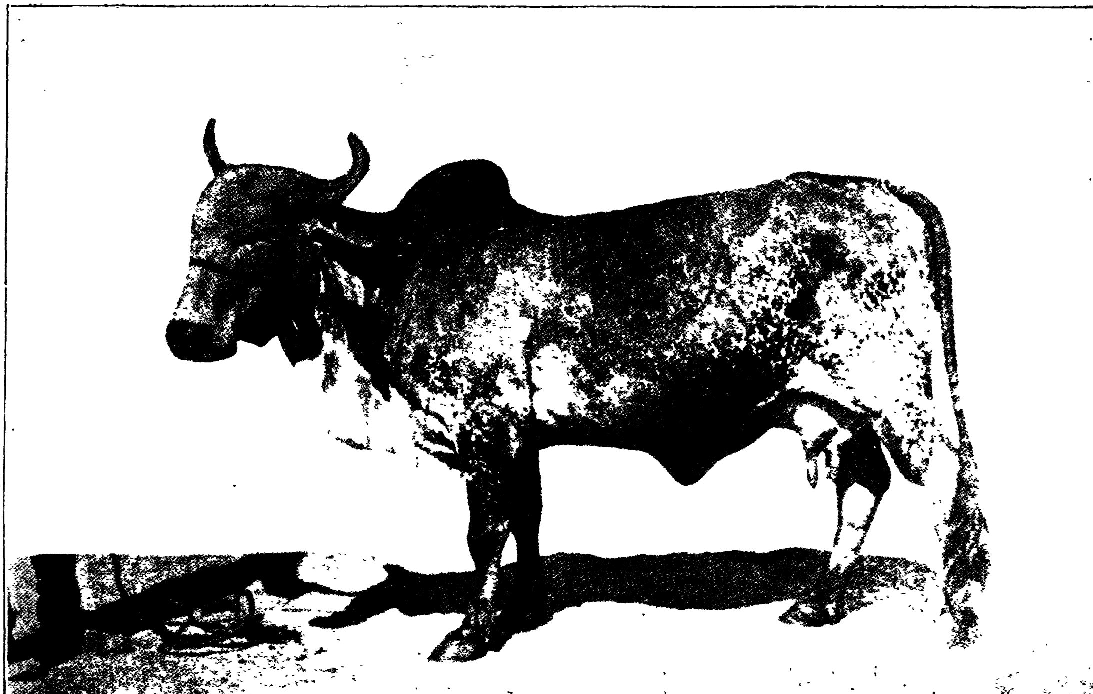
PLATE VII.
SANIWAHL COW.



From a Photograph taken at the Government Military Dairy Farm, Kirkee.

PLATE X.
DECCANI COW.

PLATE VI.
GIR COW.



From Hewlett's "Breeds of Cattle in the Bombay Presidency."

PLATE VIII.
HANSI COW.

PLATE IX.

GUJARATI COW.

From a Photograph taken in Bombay.

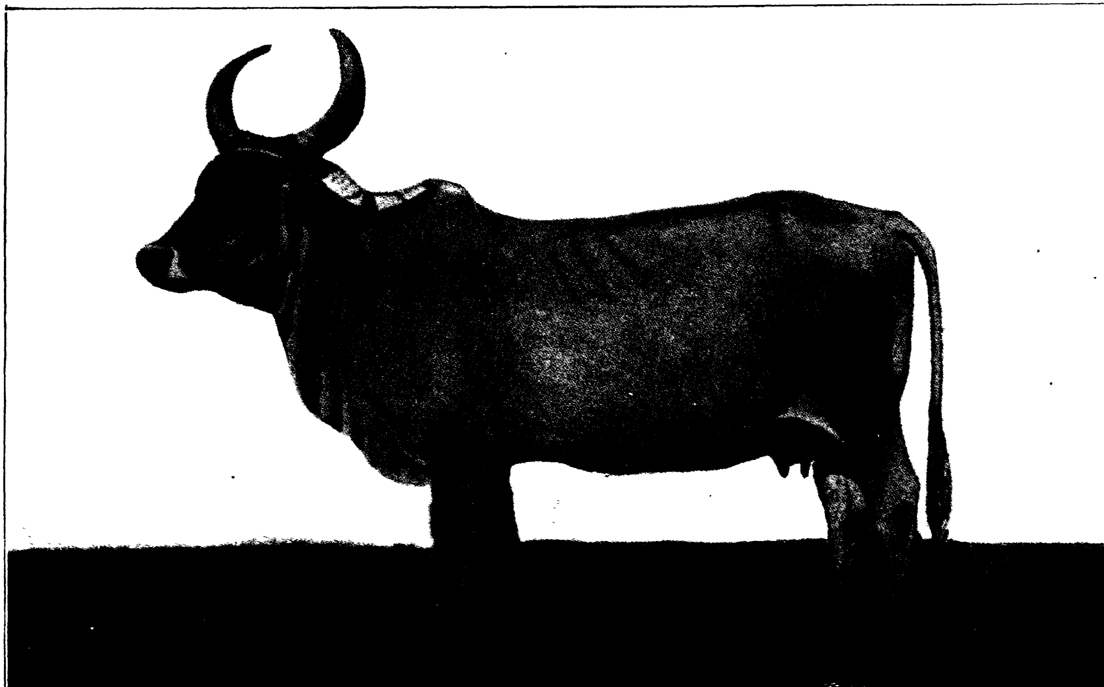
PLATE XII.

AMRIT—MAHAL COW.

This was a favourite cow at the Mysore Palace.

PLATE XIV.

KANKREJI COW.



From Hewlett's "Breeds of Cattle in the Bombay Presidency."

PLATE XV.

KRISHNA VALLEY COW

PLATE XVI.

SHAHABAD CATTLE.

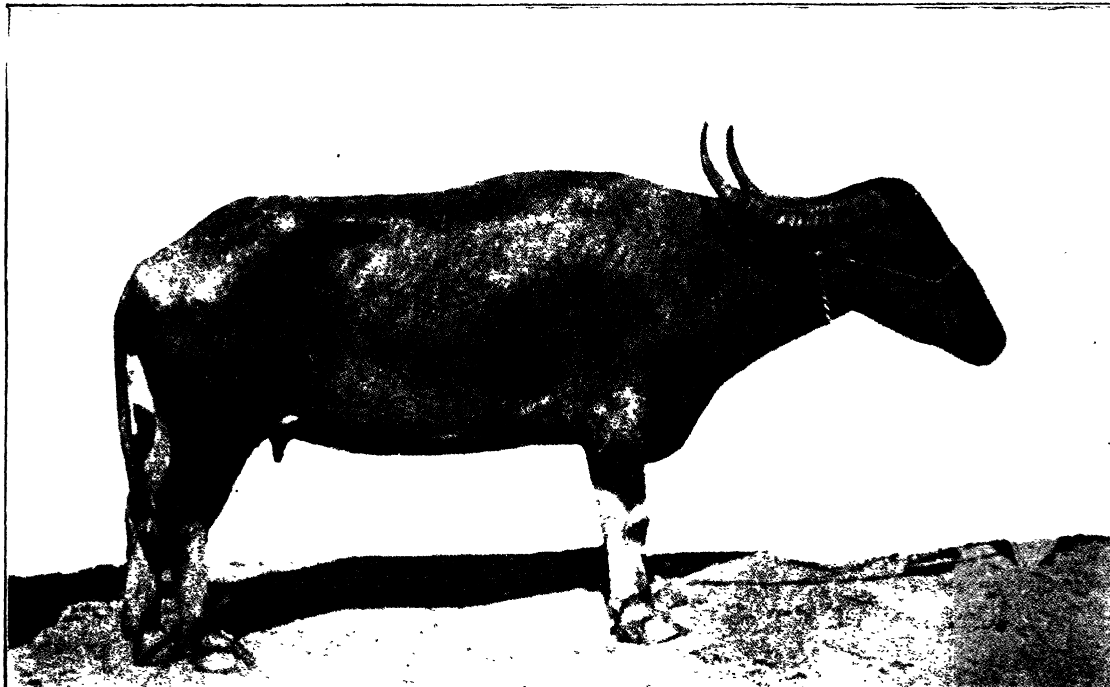
From a Photograph kindly sent by Mr. G. Milne, I.C.S. ...

PLATE XVII.

GIR BULL.

From a Photograph taken in Bombay.

PLATE XVIII.
DECCANI BUFFALO.



From Hewlett's "Breeds of Cattle in the Bombay Presidency."

PLATE XIX.

VARADHI (NAGPUR) BUFFALO.

From Hewlett's "Breeds of Cattle in the Bombay Presidency."

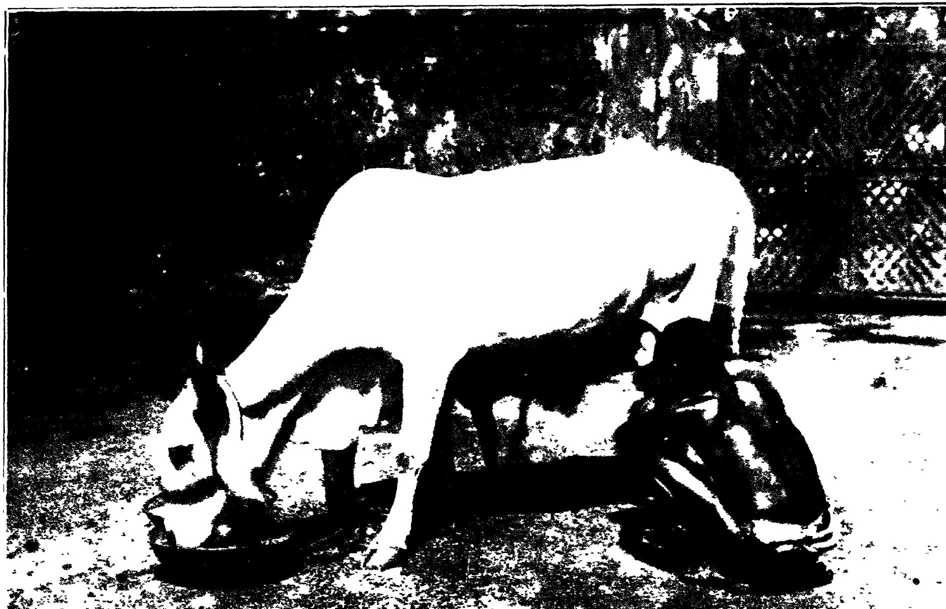
PLATE XX.

JAFFRABADI BUFFALO BULL.

From Hewlett's "Breeds of Cattle in the Bombay Presidency."

PLATE XXI.

METHOD OF MILKING.



From a Photograph taken in Bombay.

PLATE XXII.

ONE OF THE MODES OF CARRYING MILK IN BOMBAY.

PLATE XXIII.

TRANSIT OF MILK IN BOMBAY.

PLATE XXIV.

TRANSIT OF MILK IN BOMBAY.

THE NEW WAY.

PLATE XXV.

A MILK SHOP IN BOMBAY.

A sample of milk taken from this place contained *acid-fast bacilli.*

From a block kindly lent by Dr. J. A. Turner.

PLATE XXVI.

A MILK SHOP IN KAMATIPURA, BOMBAY.

Milk collected from here also showed *acid-fast bacilli.*

From a block kindly lent by Dr. J. A. T

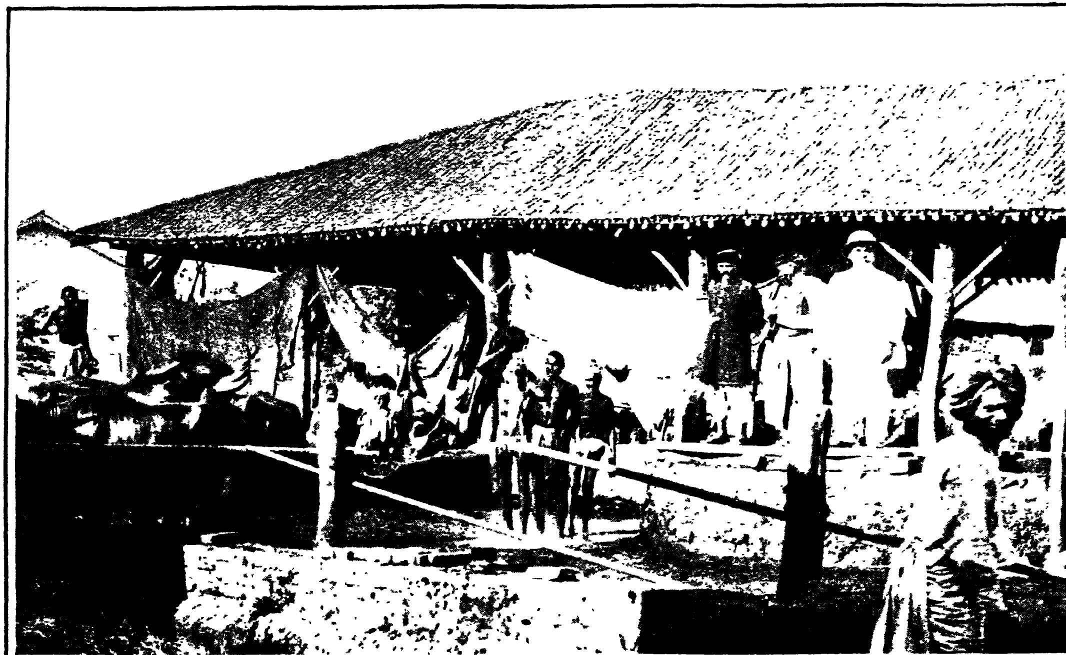
PLATE XXVII.

POURING MILK INTO VESSELS FOR RETAIL.

From a block kindly lent by Dr. J. A. Turner.

PLATE XXVIII.

WASHING PLACE FOR BUFFALOES, near a Bombay Cattle Stable.



ıe Gowlees are seen washing themselves, then buffaloes and milk vessels. *From a block kindly lent by Dr. J. A. Turner.*

PLATE XXIX.

COW-SHED IN KAMATIPURA. BOMBAY.

Milk collected from this place contained *acid-fast bacilli*. The cows reacted to Tuberculin.

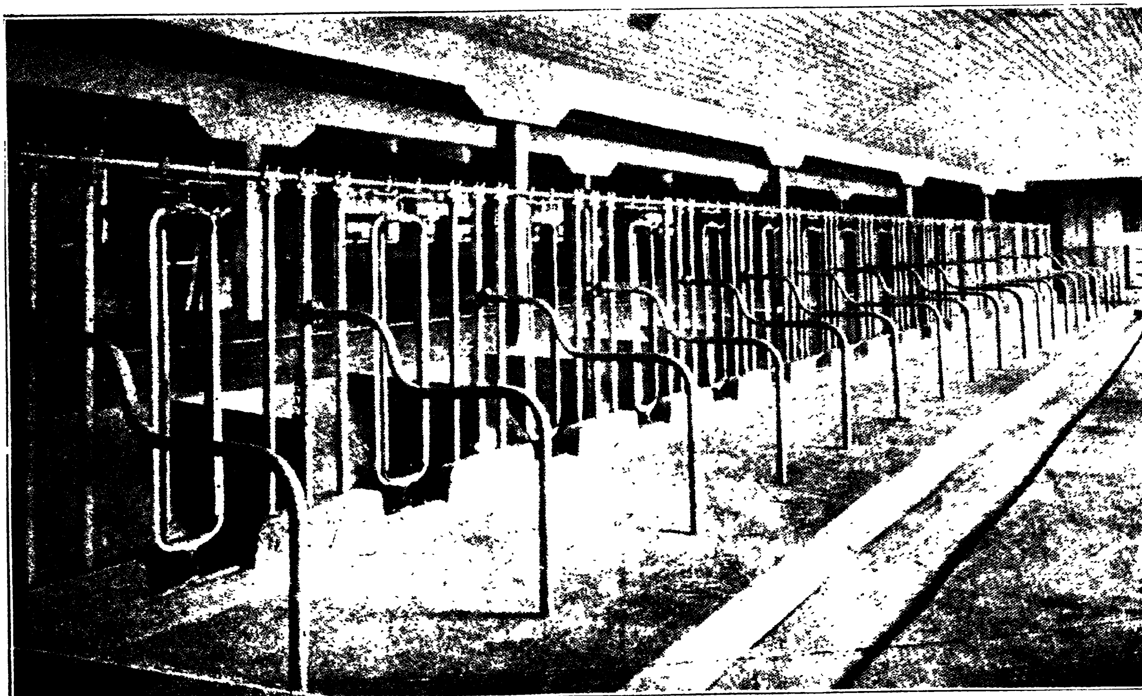
PLATE XXX.

AN INSANITARY MILCH CATTLE STABLE IN BOMBAY.

This represents a corner of a buffalo stable in a crowded locality in Bombay. This type of stable is gradually disappearing.

PLATE XXXI.

A MODERN SANITARY MILCH CATTLE STABLE IN THE U S.A.



This is a portion of a barn of the Michigan Agricultural College, East Lansing, Mich., U.S.A., and is taken from a Photograph published by the Kent Manufacturing Co. Ft. Atkinson, Wisconsin.

APPENDIX A.

Note on the cost of establishing a collecting station for about 2,000 lbs of milk to be pasteurised and water-cooled, for despatch by train or motor to a distance not exceeding 50 miles with suitably timed trains :—

	Rs.
Dairy buildings with tiled roof, patent stone floor, gauzed windows and doors, 12′ × 16′ with wash-up room 10′ × 8′ and office 10′ × 8′ or plinth area 26′ × 20′ = 520 @ Rs. 3.	1,560
Water tank, drains, small pump, etc.	440
Total for Buildings . ..	2,000
Boiler, vertical cross tube, 5″ × 6″ × 3″ = 80 lbs pressure complete with fittings mounting and No 4 Injector and 20 ft chimney	700
Lawrence Water-Cooler . .	80
"Direct Motor" steam driven pasteuriser, size "C," elevating type	550
Milk Tank, 4′ × 3′ × 1½′	80
Gerber Butyrometer Lux 4 Test, complete	60
Milk Recorder with Pail and Tripod	35
24 "Firsteel cans—17 galls, 15 galls, and 10 gallons ..	500
1 set measures—1 gallon, ½ gallon, 21 lbs and 1 lb	10
1 Hygiea Filter with 500 spare mediums	45
1 Steaming Block	10
1 Wash-up Tank	50
1 Set Seals and Pincers	80
Miscellaneous Contingencies, i e, stationery, small safe, soap, soda, lactometers, thermometers, etc.	300
Total ..	2,500

(Sd) G H FROST,
Assistant Director, Military Dairies,
Southern Circle.

APPENDIX B.

Note on Co-operative Dairy Societies in the Bombay Presidency :

I. Alibag Co-operative Dairy Society, Limited —

Date of registration—23rd April 1915.

Number of members—35, of whom 28 are cultivators producing milk and marketing it through the Society. Capital Rs. 1,152-8-0. Milk is obtained from the villages of Veshwi and Mula, which are at a distance of 2 miles from the town of Alibag.

Method of collecting, transporting and distributing milk.—The Society has put up two milking sheds at a cost of Rs 340, one at Veshwi and the other at Mula. The members keep their animals in their own houses, but bring them to the Society's milking sheds twice a day at the appointed hours at

which they milk them under the supervision of the representatives of the managing committee. The Society keeps its own milking pails, and each member is provided with a pail for drawing the milk. The milk is measured and handed over to the Society. Each member carries a pass-book with him, in which the quantities supplied by him to the Society are regularly entered. All milk thus collected at each centre is put into a big brass can, which is locked and sent to the town (on head load) with a servant of the Society for delivery to registered customers.

Cleanliness.—All the pails, cans and other utensils of the Society are kept in a perfectly clean condition. Every utensil used in handling milk is first washed in cold water, then in warm water with some washing soda in it, and finally in boiling water, and dried. Before milk is drawn from the animals, the hands of the milker and the udders of the animals are washed and wiped with muslin. Bar-soap is freely used.

The total number of customers is 76, and the total quantity of milk supplied to them in September 1915 was 2,700 seers. All milk taken by the Society from the members is distributed to customers, and no surplus is left on hand.

Advantages to members.—The Society takes milk from the members at a little over nine seers a rupee and supplies it at eight seers a rupee to the customers. After deducting expenses, a small margin of profit is left to the Society. Though the members are prevented from adulterating their milk with water, they get good prices and save a good deal of time, which they used to spend (before joining the Society) in hawking about their milk. They are entirely satisfied with the prices which they now get. Besides, they get loans from the Society at 9⅜ per cent. for purchasing animals and foodstuffs.

Advantages to customers.—The public of Alibag are fully satisfied with the quality and the price of the milk.

Remarks.—The Society is now arranging to keep a good buffalo breeding bull for serving the members' she-buffaloes. It has also secured some grazing land from the Collector for the use of the members' she-buffaloes, which, with the bull proposed to be obtained from Gujarat, are to be constituted into a herd.

II. Belgaum Co-operative Dairy Society, Ltd.—This Society consists of 24 members, of whom 20 are milk-producing Gowlees who supply their milk to the Society. The Gowlees at present keep their animals in the town and bring them to two milking centres for milking them under the supervision of the manager. The arrangements as regards cleanliness and the collection, transport and distribution of milk are similar to those of the Alibag Dairy Society. The Society has applied to the Municipality for building a shed outside the town for housing the animals of the members of the Society. The Belgaum Dairy Society markets about 3,500 seers of milk a month. The public of Belgaum are entirely satisfied with the quality and price of the milk.

III. Thana Co-operative Dairy Society, Ltd.—This Society has got a shed in which some animals of the members are kept; other members keep their animals in small huts near the Society's shed. Milk is drawn in the presence of the manager. The arrangements as regards cleanliness and transporting and distributing milk are exactly on the lines of the Alibag Society. The total quantity of milk marketed by the Society every month is about 6,000 seers. The Thana people are fully satisfied with the quality of milk. In this Society, some of the producing members are Gowlees (bhayyas) and others non-gowlees. The Society has secured more than 200 families as its customers.

IV. The Gomatipur Co-operative Dairy Society, near Ahmedabad.—This Society has only very recently begun to supply pure and unadulterated milk to the city of Ahmedabad.

A proposal for starting a dairy society of cultivators at Asarwa for supplying pure milk to Ahmedabad has been received.

V. The Bhandup Co-operative Dairy Society for supplying pure milk to Bombay has been recently formed.

VI. Proposals for establishing co-operative dairy societies at Gadag and Hubli for improving the milk-supplies of those towns are under consideration.

VII. Similarly, there are proposals for establishing dairy societies at Kotrud and Talegaon for supplying pure milk to the city of Poona.

(Sd.) V. H. GONEHALLI,
Assistant Registrar, Co-operative Societies,
Bombay Presidency.

APPENDIX C.

Form of License used in Bombay.

No. OF 1915—1916.

License for carrying on within the City the trade or business of a dealer in or importer or seller or hawker of milk and for using premises in the City for the sale of milk.

PURSUANT to the provisions of Sections 412A (*a*) and (*b*) and 479 of "The City of Bombay Municipal Act, 1888" as amended by Acts. Nos. II of 1911 and VI of 1913, Mr...of Bombay, is hereby licensed for the period of one year, namely, FROM 1ST APRIL 19..TO 31ST MARCH 19..to carry on within the City the trade or business of a dealer in or importer or seller or hawker of milk and to use for the sale of milk the room or shop or place measuring..........................Sq. Ft., being part of the premises No...Ward, Bombay, subject, however, to the restrictions and conditions following, that is to say—

1. The Licensee shall not himself or through his servants import into Bombay or transport or hawk or expose or offer for sale in Bombay any milk which has been adulterated by adding to or mixing with it any water or other substance for the purpose of increasing the bulk or measure thereof.

2. The Licensee and his servants when importing any milk into Bombay or transporting or hawking or exposing or offering for sale any milk in Bombay shall whenever required so to do by a Municipal Inspector of the Licensing or Health Department sell to such Inspector at a reasonable price a sample or samples of such milk not more in quantity than shall be reasonably requisite for the purpose of examination by analysis or other test, and shall not remove or permit the removal of the milk from which such sample or samples has or have been so taken until such examination has been made.

3. The Licensee shall not at any one time keep or permit to be kept in the said room or shop or place (hereinafter referred to as the said premises) any greater aggregate quantity of milk than..........................

4. The Licensee shall cause the floor and drains of every part of the said premises and every counter, shelf or bench on which vessels containing milk are kept to be thoroughly cleansed with water at least once in every day.

5. The Licensee shall cause the floor of the said premises to be paved throughout with suitable impervious material to be approved by the Muni-

cipal Commissioner and the paving shall be sloped in such a manner as to ensure the effectual drainage of the said premises, the gradient of such paving being not less than 1 in 30.

6. The Licensee shall cause every part of the internal surface of the walls and ceiling of the said premises to be thoroughly lime washed at least once in every year, and oftener, if so required by the Municipal Commissioner.

7. The Licensee shall not deposit or keep any milk for sale—

(*a*) in any stable;

(*b*) in any room or place where it would be liable to become infected or contaminated by impure air or by any offensive, noxious or deleterious gas or substance, or by any noxious or injurious emanation, exhalation or effluvium;

(*c*) in any room used as a kitchen or as a living room;

(*d*) in any room where any other trade disapproved by the Municipal Commissioner is carried on;

(*e*) in any room or building or part of a building communicating directly by door, window or otherwise with any room used as a sleeping room or in which there may be any person suffering from any infectious or contagious disease or which may have been used by any person suffering from any such disease and may not have been properly disinfected;

(*f*) in any room or building or part of a building in which there may be any direct inlet to any drain or which opens on to a gully or with which a privy or water-closet communicates directly.

8. The Licensee shall not keep any milk intended for sale in open vessels, but every vessel containing such milk shall be provided with a suitable cover.

9. The Licensee shall not retail milk to his customers by dipping his hands into the vessel containing the same and every such vessel shall in cases where the Municipal Commissioner shall so require be provided with a tap at the lower end through which the milk shall be drawn.

10. The Licensee shall have his name and address clearly marked upon all vehicles and cans used by him for the sale of milk or for conveying milk for sale.

11. No buffalo milk sold or exposed for sale by the Licensee shall contain less than five per cent. of fat nor less than nine per cent. of solids not fat and no cow milk sold or exposed as aforesaid shall contain less than 3·5 per cent. of fat nor less than 8·5 per cent. of solids not fat.

12. The Licensee shall not cause or suffer any cow or buffalo belonging to him or under his care or control to be milked for the purpose of obtaining milk for sale—

(*a*) unless, at the time of milking, the udder and teats of such cow or buffalo are thoroughly clean; and

(*b*) unless the hands of the person milking such cow or buffalo also are thoroughly clean and free from all infection and contamination.

13. The Licensee shall take all reasonable and proper precautions in connection with the collection, storage and distribution of the milk, and otherwise to prevent the exposure of the milk to any infection or contamination.

14. The Licensee shall not allow any person suffering from any dangerous or infectious disease or having been recently in contact with a person so suffering to milk any cow or buffalo or to handle any vessel used for containing milk for sale or in any way to take part or assist in the conduct of the trade or business of this License so far as regards the production, distribution or storage of milk and the Licensee shall not if himself so suffering or having recently been in contact as aforesaid milk any cow or buffalo or handle any

vessel used for containing milk for sale or in any way take part in the conduct of the trade or business as far as regards the production, distribution or storage of milk.

15. The Licensee shall not keep milk for sale, or cause or suffer any such milk to be placed in any vessel, receptacle or utensil which is not thoroughly clean.

16. The Licensee shall cause every vessel, receptacle or utensil used by him for containing milk for sale to be thoroughly cleansed with steam or clean boiling water before and after it shall have been used, and to be maintained in a constant state of cleanliness.

17. The Licensee shall not convey any milk for sale or distribution in open vessels but all vessels containing such milk shall be provided with proper close fitting covers and in cases where the Municipal Commissioner shall so require a tap at the lower end through which the milk shall be retailed to the customers. If the milk is distributed in cans such cans shall also be provided with properly fixed covers.

18. The Licensee shall not at any time mix with other milk or sell or use for human food the milk of any cow or buffalo which may be suffering from Tuberculosis, Rinderpest or Foot and Mouth Disease or from any disease of the udder which may be certified by a Veterinary Surgeon to be Tubercular.

19. The Licensee shall not keep or permit to be kept outside the said premises or on the public road or street any tins, drums or other vessels used or intended to be used for containing milk.

20. This License is valid only for the said premises and for the quantity of milk herein specified and if the Licensee at any time during the period of this License desires to use any additional room or shop or any additional space for keeping milk or to keep an additional quantity of milk, he must apply for a fresh license which (if granted) will be subject to the payment of such additional or extra fee as may for the time being be properly chargeable in respect thereof.

21. If the Licensee intends to vacate or give up possession of the said premises during the period of this License he shall forthwith inform the Deputy Health Officer—Ward of his intention so to do.

22. This License is not transferable either as regards the person to whom or the premises for which it is granted, without the written permission of the Municipal Commissioner.

23. The Licensee shall cause this License to be affixed in some conspicuous part of the said premises.

24. If the Licensee entertains any servants for the purpose of carrying on this trade, he shall provide them with such badges or authorities as the Commissioner may direct.

25. The Licensee will at all times during the continuance of this License, be responsible for the due fulfilment and observance of all the foregoing conditions, and in case of any infringement of, or neglect or failure on the part of the Licensee or of any other person to fulfil or observe any of the said conditions, the Licensee will be liable to prosecution and to suspension or revocation of this License.

26. The fee chargeable for this License as fixed by the Municipal Commissioner with the sanction of the Municipal Corporation under Section 479 (2) and Section 412A (*a*) and (*b*) of the City of Bombay Municipal Act aforesaid is Rs. (   )....................................ONLY.

PUBLIC HEALTH DEPARTMENT,
BOMBAY MUNICIPALITY,
................191 .

Deputy Health Officer,

..................*Ward.*

Municipal Commissioner,
for the City of Bombay.

APPENDIX D.

Bye-Laws relating to Milch Cattle Stables made by the Municipal Corporation of the City of Bombay in exercise of the powers conferred by Section 461 (*f*), (*g*), and (*h*) of the City of Bombay Municipal Act, 1888 and confirmed by the Municipal Corporation at a meeting held on 24th November 1913, and by Government by notification No. 675, dated 26th January 1914, published in the "Bombay Government Gazette," of the 29th January 1914.

GENERAL.

1. A person or firm having a license from the Commissioner to use any premises for the purpose of keeping Milch Cattle is in these bye-laws referred to as "a License-holder," and the premises to which any such license relates are referred to as "licensed premises."

2. "Dairy" means a place in which milk, butter or other products of milk are stored, made or kept for sale, or are sold.

3. "Stable" means any building used or intended to be used for keeping Milch Cattle.

PREMISES LICENSED FOR KEEPING MILCH CATTLE.

4. A person shall not be entitled to a license to use for keeping Milch Cattle any stable which does not fulfil the conditions prescribed by bye-law 6. One such license only will be granted in respect of the whole of any premises, notwithstanding that such premises are so used or intended to be used by more persons than one occupying severally.

5. A license-holder shall not at any time of the day or night—
   (*a*) keep on the licensed premises a larger number of Milch Cattle than the number allowed by his license;
   (*b*) keep in any one stable on the licensed premises a larger number of Milch Cattle than the stabling capacity of such stable or shed will admit of according to the standard of floor space prescribed by bye-law 6 (*e*);
   (*c*) in any case, keep in any one stable or shed erected on the license premises after these bye-laws came into force a larger number of Milch Cattle than 100.

6. A license-holder shall not use for keeping Milch Cattle any stable on the licensed premises which does not fulfil the following conditions, namely:—
   (*a*) its height shall be not less than twelve feet measured from the floors of stalls to the wall-plate;
   (*b*) it shall have an open space of not less than fifteen feet in width all round it, such width to be measured from the outer sides of the external posts:
   (*c*) its floor surface shall be at least one foot higher than the mesne level of such surrounding open space, and its situation shall such as to admit of its being properly drained into a drain or place legally set apart for the discharge of drainage;
   (*d*) it shall be open on all sides to such surrounding open space, but may be fitted with such screens or weather boards as the Commissioner may in each case approve;

(e) it shall be so constructed as to afford floor space not less than twelve-and-a-half feet in length by five feet in breadth for each cow or buffalo to be stabled therein, such space to be inclusive of space occupied by any manger, central or side drain, or central passage.

7. A license-holder and every person using for keeping Milch Cattle any portion of the licensed premises shall, from time to time whenever required by the Commissioner so to do, furnish to the Commissioner a statement in writing containing the correct name of each person who owns any of the Milch Cattle for the time being kept upon the licensed premises, and of the number of Milch Cattle owned by each such person.

Dung not to be deposited so as to pollute water.

8. A license-holder shall not cause or suffer the dung of any Milch Cattle kept on the licensed premises to be deposited in such a situation or in such a manner as to pollute any water supplied for use or used or likely to be used by man for drinking or domestic purposes, or any water used or likely to be used by Milch Cattle or horses or other four-footed animals, or in any dairy or for cleaning or washing vessels used or intended for milk.

Floors to be paved so as to prevent soakage.

9. A license-holder shall cause the floor of every stable to be paved with impervious material approved by the Commissioner and sloped with a gradient of not less than 1 in 30 to the satisfaction of the Commissioner so as to prevent any soakage into the gound of urine or other filth.

Receptacle for dung to be provided.

10. A license-holder shall provide upon or in some convenient place in the immediate neighbourhood of the licensed premises a suitable receptacle or receptacles for dung, manure, soil, filth or other offensive or noxious matter which may from time to time be produced in the keeping of Milch Cattle upon the premises. Such receptacle or receptacles may be constructed of masonry or, may be movable on wheels, but in the latter case shall be lined with tin plates or dammered internally to the satisfaction of the Commissioner. Such receptacle or receptacles shall have an aggregate internal space portionate to the number of animals kept in the licensed premises, and such space shall not be less than 1½ cubic feet for each head of cattle so kept.

With floor not lower than surface of adjoining ground.

He shall cause such receptacle or receptacles to be constructed so that the bottom or floor thereof shall be in each case at least 1½ feet higher than the surface of the ground adjoining such receptacles.

To be so constructed as to prevent escape or soakage of contents.

He shall also cause such receptacle or receptacles to be constructed in such a manner and of such materials and to be maintained at all times in such a condition as to prevent any escape of the contents thereof or any soakage therefrom into the ground or into the wall of any building.

To be furnished with cover.

He shall if so required by the Commissioner cause each such receptacle to be furnished with a suitable tin, tile or jowli roof. He may provide a loft for storage of hay over any stable on the licensed premises, but not so that any part of any such loft will be less than 12 feet above the floors of stalls.

Gowlis not to sleep in stable, and lofts, &c., not to be inhabited.

He shall not permit any gowli or other person to sleep in any stable, nor shall he permit any loft or part of the premises over a stable to be used for purposes of human habitation. Provided that the Commissioner may permit such specified number, as he may think fit, of attendants to

sleep on the premises, to prevent accident among the animals; but no attendant shall occupy any space which will encroach upon the air space prescribed for each animal.

Paved space for washing animals to be provided.

11. A license-holder shall also provide upon or in connection with the licensed premises a paved space to the satisfaction of the Commissioner on which the cattle can be washed. Such paved space shall have an area equal to not less than 1-7th of the floor area of the stable.

Drainage to be maintained in good order.

12. A license-holder shall also cause every drain or means of drainage upon or in connection with the licensed premises to be maintained at all times in good order and efficient action to the satisfaction of the Commissioner.

Premises to be thoroughly cleansed daily.

13. (*a*) A license-holder shall twice daily—morning and evening—cause the licensed premises to be thoroughly cleansed and flushed and shall cause to be removed from the receptacle or receptacles provided in accordance with the requirements of bye-law 10, all dung, manure, soil, filth, urine or other offensive or noxious matter produced in or upon the premises and placed or accumulated in such receptacle and shall cause the same to be deposited in such place or places as the Commissioner shall from time to time direct.

Not more than four days' supply of hay, grass or straw to be stored at any one time.

(*b*) He shall not cause or suffer a greater quantity of hay, grass or straw to be kept or stored on the licensed premises at any one time than will suffice to meet the requirement of four days of the animals stabled therein.

Storage of hay, &c., not to curtail minimum space for animals.

He shall not by storing the hay, grass or straw, encroach on or diminish in any way the minimum space for animals prescribed by bye-law 6 (*e*).

No fire to be allowed near hay, &c.

He shall not cause or allow any fire to be lighted in a stable or in any portion of the licensed premises near to any hay, grass or straw stored therein.

To bring out animals for inspection if required.

14. A license-holder shall, whenever required by the Commissioner, bring out or cause to be brought out from each stable on the licensed premises for the purpose of inspection all or any of the Milch Cattle which may for the time being be stabled therein and shall provide every such facility as may be required for enabling the person making such inspection to thoroughly examine the said animals or any of them.

LICENSED PREMISES AND PREMISES OCCUPIED BY DAIRY-MEN AND MILK-SELLERS.

To provide water from Municipal main.

15. A license-holder, dairy-man or milk-seller shall provide a sufficient supply of water from a Municipal main to the premises licensed to or occupied by him for carrying on his trade, and shall not without the previous approval in writing of the Commissioner cause of suffer any water drawn from a well to be used for or supplied to any Milch Cattle.

To alter (if required) licensed premises not fulfilling requirements of next succeeding bye-law as to new dairies or Cattle sheds.

16. A license-holder, dairy-man or milk-seller whose premises do not fulfil the requirements of the next succeeding bye-law respecting new dairies or stables shall so far alter the said premises or any part thereof as the Commissioner shall from time to time by notice in writing require for the purpose of bringing the same into conformity so far as may be deemed necessary with the said requirements or any of them.

17. A person who shall erect a new dairy or cattle-shed for the stabling of Milch Cattle belonging to dairy-men or milk-sellers shall construct the same in accordance with the following rules :—

Regulations for construction of new dairies or cattle sheds.

(*a*) The roof shall be tiled or covered with corrugated sheet iron.

Roof.

(*b*) The floor shall be paved throughout with suitable impervious material approved by the Commissioner and the paving shall be so sloped as to ensure effectual drainage having a gradient of not less than 1 in 30.

Floor.

(*c*) The stable shall be fitted with mangers 2½ feet in width, and if the mangers are so arranged that the animals in two rows face each other, a passage of at least 3 feet in width shall be left between the two rows of mangers. The floor of this passage shall be paved in the same manner as the floor of the stables, and the passage shall at all times be kept free of obstruction.

(*d*) The stable shall be drained by an open ovoid drain of such materials and dimensions with such fall and laid in such position and manner in all respects as the Commissioner shall require and such drain shall be connected with such sewer or other means of drainage as the Commissioner shall direct.

18. A person shall not erect a new stable for Milch Cattle belonging to dairy-men or milk-sellers within a distance of 15 feet from any street or 25 feet from any dwelling house.

Not to be within 15 feet from any street or 25 feet from any dwelling house.

19. A dairy-man or milk-seller shall not sell or keep milk in any dwelling house or room or place used for sleeping or cooking or where other articles of food are kept or where any other trade is carried on.

Milk not to be sold or kept in dwelling houses, &c.

20. A dairy-man or milk-seller shall cause every part of the internal surface of the walls and ceiling of every room or place in which milk is kept or sold by him to be thoroughly lime-washed twice at least in every year or oftener if so required by the Commissioner.

Internal surfaces of walls and celings to be lime-washed periodically.

He shall also cause the floor of every such room or place to be paved throughout with suitable impervious material approved by the Commissioner and the paving shall be so sloped as to ensure effectual drainage having a gradient of not less than 1 in 30.

He shall also cause the floor and drain of every such room or place and every counter, shelf or bench on which milk vessels are kept to be washed and thoroughly cleansed daily.

Floors, counters, shelves, &c., to be cleansed.

21. A dairy-man or milk-seller shall cause every vessel used in his milk-shop or in the distribution of his milk to be rinsed with boiling water and thoroughly cleansed before and after use.

Milk vessels to be rinsed and thoroughly cleansed before and after use.

22. A dairy-man or milk-seller shall not use or permit to be used for the washing and cleansing of milk vessels any water except such as is drawn from a Municipal main or from a well to be previously approved in writing by the Commissioner.

Water from Municipal mains and approved wells only to be used for washing milk vessels.

APPENDIX E.

Extracts from the Bombay Prevention of Adulteration Act., 1899.

(As modified up to the 1st July, 1909.)

Provisions which relate to the sale of food, and which may by notification be made applicable to any food.

3. (1) Whoever sells to the prejudice of the purchaser any article of food which is not of the nature, substance or quality of the article demanded by such purchaser, shall be punished for the first offence with fine which may extend to one hundred rupees, and for a second or any subsequent offence with fine which may extend to five hundred rupees.

(2) Provided that no offence shall be deemed to have been committed under this section in the following cases, that is to say,—

(*a*) where any matter or ingredient not injurious to health has been added to the article of food, because the same is required for the production or preparation thereof, as an article of commerce, in a state fit for carriage or consumption, and not fraudulently to increase the bulk, weight or measure of the food or conceal the inferior quality thereof.

(*b*) where in the process of production, preparation or conveyance of such article of food some extraneous substance has unvoidably become intermixed therewtih,

(*c*) where any matter or ingredient not injurious to health has been added to or mixed with such article of food and, before the sale thereof, the seller has brought to the notice of the purchaser, either by means of a label distinctly and legibly written or printed on or with the article or otherwise, the fact that such matter or ingredient has been so added or mixed.

Explanation :—If in compliance with a demand for ghee any article is supplied which contains any substance not exclusively derived from milk, such article shall be deemed to have been sold to the prejudice of the purchaser within the meaning of sub-section (1), unless before the sale thereof the seller has brought to the notice of the purchaser the fact that it contains such substance.

(3) In any prosecution under this section it shall be no defence to allege that the vendor was ignorant of the nature, substance or quality of the article sold by him, or that the purchaser having bought only for analysis was not prejudiced by the sale.

Provided that the vendor shall not be deemed to have committed an offence under this section, if he proves to the satisfaction of the Court—

(*a*) that the article sold was purchased by him as the same in nature, substance and quality as that demanded by the purchaser, and with a written warrant to the effect that it was of such nature, substance and quality,

(*b*) that he had no reason to believe at the time when he sold it that the article was not of such nature, substance and quality as aforesaid, and

(*c*) that he sold it in the same state in which he purchased it.

4. (1) If in the City of Bombay the Commissioner or any officer empowered by him in that behalf, or elsewhere the officer authorized by the Municipality for the purposes of section 142 of the Bombay District Municipal Act, 1901, shall apply to purchase any article of food exposed for sale and shall tender the price for a quantity not more than shall be reasonably requisite for the purpose of analysis, and the person exposing the same for sale shall refuse to sell the same, such person shall be liable to a penalty no exceeding fifty rupees.

(2) The Commissioner or officer empowered as aforesaid in the City of Bombay, and elsewhere the officer authorised by the Municipality as aforesaid, on purchasing any article under this section for the purposes of analysis, shall, after the purchase shall have been completed, forthwith notify to the seller or his agent selling the article his intention to have the same analysed by the Chemical Analyser to Government, and shall offer to divide the article into three parts to be then and there separated and each part to be marked and sealed or fastened up in such manner as its nature will permit, and shall, if required to do so, proceed accordingly, and shall deliver one of the parts to the seller or his agent.

He shall afterwards retain one of the said parts for future comparison and submit the third part, if he deems it right to have the article analysed, to the Chemical Analyser to Government.

(3) If the seller or his agent do not accept the offer of the purchaser as aforesaid to divide the article purchased in his presence, the Chemical Analyser to Government receiving the article for analysis shall divide the same into two parts, and shall seal or fasten up one of those parts and shall cause it, either upon receipt of the sample or when he supplies his certificate, to be delivered to the purchaser, who shall retain the same for production in case proceedings shall afterwards be taken in the matter.

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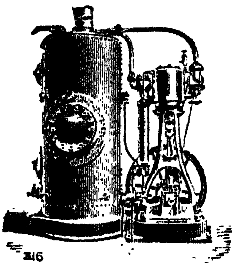

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